Inventory of Shoreline Habitat and Riparian Conditions of the Green/Duwamish River Within the City of Tukwila

Draft

Prepared for
City of Tukwila

January 7, 2003
12578-02

PENTEC ENVIRONMENTAL
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Prepared for
City of Tukwila
6300 Southcenter Boulevard
Tukwila, Washington 98188

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CONTENTS Page

CONTENTS (Continued)

TABLES

FIGURES

INTRODUCTION

The Washington Department of Ecology's (Ecology's) guidelines for revisions to Shoreline Management Plans (SMPs; WAC 173-26) set forth a requirement for an inventory of existing shoreline uses and habitat conditions as part of the process of determining appropriate uses within the shorelines. The guidelines also called for the identification of existing high-quality habitats within each jurisdiction that should be preserved, and the identification and prioritization of habitat restoration opportunities. Although the initial guidelines were invalidated by the Shoreline Hearings Board, it is expected that these requirements will remain an essential part of the SMP updates mandated by the Growth Management Act; indeed, the City of Everett has been commended by Ecology for the inventory process used in that city's recent SMP revisions, now approved by Ecology.

The City of Tukwila (City) contracted with Pentec Environmental (Pentec), a Division of Hart Crowser, Inc., to provide an inventory of existing instream and riparian conditions. This inventory was needed to allow preparation of detailed maps of the City's existing shoreline conditions and to provide a standardized set of data applicable to the entire shoreline length of the City. In addition to its anticipated use in Tukwila's SMP update, the inventory also will be useful for regional salmonid habitat restoration plans under preparation by the Water Resource Inventory Area (WRIA) 9 Planning Work Group or other parties.

This report builds on earlier work completed for the City, in which Pentec (2002) reviewed the scientific literature on the role and effectiveness of riparian vegetation in protecting and enhancing aquatic functions in adjacent waters. That report also describes in general the relative performance of riparian functions along the Green/Duwamish mainstem and discusses the dilemma facing the City: How to adequately protect and restore riparian areas in the built environment of the City's shorelines while maintaining a healthy economic climate and quality of life. This report provides the inventory of riparian conditions and vegetation necessary to inform those decisions. The report also serves to identify existing high-quality habitats and to identify and prioritize potential restoration opportunities. Finally, recommendations are provided on possible uses of the data assembled and their significance to issues of appropriate buffer widths and restoration of habitat function in the City's shorelines.

THE GREEN/DUWAMISH RIVER

The City of Tukwila's present city limits encompass the Green/Duwamish River from river mile (RM) 16 (left [west] bank; about RM 15.7 right bank) in the fluvial freshwater portion of the Green River to RM 3.7 (right bank; 5.1 left bank) in the tidal and brackish Duwamish estuary (Figure 1). Anticipated annexation may extend the city limits upriver along the left bank to about RM 17.3. The extent of tidal influence, and the commonly accepted upstream limit of the estuary, is at about RM 12, just downstream of the Interstate 405 (I-405) bridges.

Over the past century and a half, the Green/Duwamish River system has undergone substantial changes as the area developed into an industrial seaport and urban center (Blomberg et al. 1988, Williams et al. 2001). Before 1906, the large, unregulated freshwater outflow of the original Duwamish River included the Green, Black, Cedar, and White river basins. The combined area of the watershed historically was approximately 1,640 square miles versus its present drainage of 500 square miles (Blomberg et al. 1988). The discharge of fresh water through the lower Duwamish was estimated to have ranged between approximately 2,500 cubic feet per second (cfs) and 9,000 cfs. Present mean discharges range from under 500 cfs to about 4,000 cfs and peak flood flows have been limited by the operation of the Howard Hanson Dam to 12,000 cfs (Kerwin and Nelson 2000).

With the construction of navigation channels on the lower Duwamish in the early 1900s, 9.3 miles of meandering river were replaced with 5.3 miles of straightened federal navigation channel. This channel, which runs up to the turning basin at RM 5.3, requires periodic maintenance dredging to remove sediments brought downstream by the river. Stream sediments are largely sands, ranging to muds in deeper channel areas or back eddies. One rock outcrop at the historic Northwind Weir site (RM 6.4) is exposed at low tides and creates a rapids when the tide is falling.

The Green/Duwamish River throughout its passage through the City is almost entirely contained by levees and revetments, often hardened with bulkheads, riprap, or seawalls. As a result, natural processes of flooding and sedimentation have been severely reduced and channel migration no longer occurs. Although nearly the entire upper reach of the Duwamish River (above RM 4) is constrained by these structures, much of this armoring is present from the middle or upper intertidal zone to the top of the banks. From the toe of these structures, relatively natural, sloping mud or sand banks or shoals are present for nearly 60 percent of the in the lower zone (e.g., below about RM 11; Williams et al. 2001). A majority of the shoreline along the reach of the Duwamish River above about RM 7 is relatively densely vegetated, typically by shrubs.

Riprapped shorelines and levees are often overgrown with this shrub community, which is usually dominated by willows (*Salix* spp.) and non-native blackberries (*Rubus* spp.). These shrubs provide cover and shade, overhanging the water at middle and higher water levels, and provide litter and insect production to the aquatic system. The majority of larger trees are black cottonwood (*Populus trichocarpa*), big-leaf maple (*Acer macrophyllum*), and red alder (*Alnus rubra*). These species also provide shade, litter, and insect fallout to the aquatic system. They also occasionally fall into the river and provide the additional functions of large woody debris (LWD).

Above I-405 (RM 12), the influence of tides is slight and the river is fully contained between revetments or levees for the remainder of its course through the City (to RM 17 and upstream). The shorelines are almost completely covered with a dense riparian zone dominated by blackberries. Adjacent properties within the shorelines are devoted to commercial development or infrastructure that severely constrain the potential width of riparian vegetation. Also, regulations imposed by the U.S. Army Corps of Engineers and Federal Emergency Management Agency limit the extent of riparian vegetation that is allowed on levees (A. Levesque, King County, personal communication). The riverbed continues to be sandy with relatively few areas of highly embedded gravel or cobble visible in some riffles.

Historically, temperature, and its interaction with dissolved oxygen, has been shown to be a significant limiting factor for both juvenile and adult salmon in the Duwamish River (see summaries in Williams et al. 2001, Kerwin and Nelson 2000) and there are indications that the maximum summer temperature has been increasing over the last two decades. While high temperatures in slower-moving and tidal streams are often the result of natural causes, the general lack of shade resulting from poor riparian conditions along the lower Green River likely contribute to this problem. Water quality problems in the lower Green and Duwamish rivers have been ameliorated significantly by the diversion of the outfall from the Renton sewage treatment plant from the river in 1986 (Williams et al. 2001).

The Green/Duwamish River supports three runs of chinook salmon (*Oncorhynchus tshawytscha*), two runs of chum (*O. keta*), one run of coho (*O. kisutch*), and two runs of steelhead trout (*O. mykiss*) (Williams et al. 2001). These runs are a combination of hatchery and natural stocks, defined as naturally spawning fish that are descended from both wild and hatchery fish (WDFW and WWTIT 1994). The distribution of juvenile salmon in the Green/Duwamish estuary may be associated with the limited amount of natural habitat remaining in the waterway. Warner and Fritz (1995) found the greatest catch over shallow, sloping, soft mud beaches, and these sites produced double the catch ratios of sites with sand, gravel, or cobble substrates. This study also found the highest densities of juvenile chinook salmon in the upper estuary at RM 7.5. This area has a relatively large proportion of more natural shoreline with intertidal flats and emergent vegetation (Tanner 1991). Modest juvenile salmonid densities were also observed at the Turning Basin (RM 5.2 to 5.3; Warner and Fritz 1995). This area has a highly modified shoreline, but also has broad intertidal mudflats with some marsh vegetation. No salmon spawning occurs in the Green/Duwamish River within the city limits.

METHODS

Boundaries

Our study area includes the entire stretch of the Green/Duwamish River within the city limits of Tukwila. This includes the area (termed the South Planning Area) on the left bank of the river, from approximately RM 16 to the new South 204th Street bridge at about RM 17.3 (Figure 1); this area may be annexed from King County.

Using the City's new ortho aerial photo set (1 inch=100 feet; flown in 2000) and firsthand knowledge of the Green/Duwamish River, we established boundaries for five ecological management units (EMUs) containing relatively uniform reaches of river with consistent hydrology, shoreline ecological conditions, and adjacent land uses (Figures 2 through 6).

These EMU boundaries were further subdivided into assessment units (AUs) for more detailed mapping. AUs were delineated to be sections of shoreline that contained relatively homogeneous riparian vegetation and adjacent land use. Because conditions often varied from one side of the river to the other, AUs were delineated separately for each bank. All AUs on the left bank, facing downstream, were numbered sequentially with odd numbers; all AUs on the right bank were numbered with even numbers. In defining the specific AU boundaries in the waterward and landward directions, the following conventions were used:

- Waterward Boundary: In the lower river below the turning basin (RM 5.3), the waterward boundary was set at the edge of the dredged navigation channel or at the -10 foot mean lower low water (MLLW) contour (whichever came first). Upstream of this area, a line drawn evenly down the river centerline signifies the boundary between the right- and left-bank AUs.

- Landward Boundary: The landward AU boundaries were set at 200 feet landward from the ordinary high water (OHW) line, to include the Shoreline Management Act definition of shorelines and to include riparian zone and adjacent land-use activities.

Identification of Field Characteristics

We worked with City staff to determine the appropriate suite of field characteristics to define the shorelines of the Green/Duwamish River within the City. We began with habitat attributes from the Tidal Habitat Model (THM) used in shoreline habitat inventories conducted by Pentec in the Snohomish estuary (City of Everett and Pentec 2001). The THM field questionnaire was modified by removing questions not relevant to the shorelines of Tukwila, and adding questions to describe riparian conditions and adjacent land uses in greater detail. Stressors that reduce the quality of habitat were also included. The resulting field form is provided in Table 1. A description of the field protocols employed in answering questions on the field form is provided in Appendix A.

Use of Existing Data

Various types of data have been collected on the lower Green/Duwamish River. Given the focus of this work on accurate documentation of existing conditions of shorelines and instream habitat, we found the CAD data available from the State of the Nearshore Report (Williams et al. 2001) to be the most relevant. Collected by City and Pentec biologists in the summer of 2000, these data show the exact location of LWD, pilings, riprapped shorelines, shoal or mudflat, and bulkheading, up to RM 12.

Fieldwork and Restoration Opportunities

Field surveys for the present effort were completed in 3 days in late October 2002, by bicycle, foot, and inflatable boat. The aerial photo series was taken to the field and used as the base map. The photos also served as a primary data source for field assessment of each AU using the field form. We recorded names for the majority of the vegetation and marked restoration opportunities directly on the photos.

Restoration opportunities were grouped into the following categories, in order from most to least potential benefits to instream habitat function:

- Creation of side channels with riparian and marsh enhancements to increase overall off-channel rearing habitat area and associated wetlands;

- Levee setback to allow addition of instream LWD and bench construction with vegetation enhancements;

- Bench construction with vegetation enhancements inside existing levees or revetments; and

- Riparian enhancement on revetments, identified through field observations and a Global Information System (GIS) analysis of revetments with primarily non-native vegetation.

Restoration opportunities were then ranked by either total potential new wetted area (in the case of side-channel projects and levee setbacks), or total length of river affected (in the case of bench restorations and riparian enhancements).

GIS Database

Field data were entered into a self-populating Excel spreadsheet with look-up tables (Appendix B). Field data for the following categories were entered into the database: AU number; survey date; surveyors; bank, bank type, restoration type, land use, percent of shoreline with marsh and riparian vegetation below and above OHW, vegetation quality, LWD recruitment, LWD density, armoring type and substrate below and above OHW, percent bulkheading/riprapping of shoreline, piers and docks, other overwater structures, and dredging.

Vegetation quality was ranked from field data and aerial photos in the office using the following criteria:

- Low: grasses only, or grasses and non-native shrubs, with few trees

- Moderate: mix of native and non-native shrubs, scattered trees, or trees located back from shoreline

- High: large native trees adjacent to the river, some non-native shrubs

Low, moderate, and high designations are only representative of relative riparian vegetative conditions available along the lower Green/Duwamish River corridor, and do not reflect similar rankings put forth by any resource or management agency.

All data from the spreadsheet and the look-up tables were converted into an Access database and joined with polygon and line shapefiles of the Green/Duwamish River shoreline, to spatially map the field data. Each of the field categories is available for mapping; however, we did not create any shapefiles—all data are stored in the Access database and available to be linked to the shapefiles.

Information on the City's GIS database and access to mapped information is available from the City's GIS group (Contact: Nora Gierloff, AICP, at 206-433-7141).

RESULTS

General

A total of 67 AUs were individually surveyed. Fog limited visibility of some shoreline features during the first morning of the survey; most of these areas were subsequently revisited on the third day. AUs ranged in size from a few hundred feet to over a mile, with the largest AUs (most homogeneous shorelines) generally in EMUs 1 and 2. AUs 1.01/1.02 through 2.03/2.04 (RM 17 to about RM 14) are constrained by levies or dikes; the remainder of the study area has revetments.

Most AUs (72 percent) had riparian areas greater than 25 feet wide over 51 to 100 percent of the shoreline, regardless of vegetation quality; 7 percent had vegetation over 25 to 50 percent of the shoreline; 3 percent over 10 to 24 percent of the shoreline; and 16 percent of AUs had little to no (10 percent or less) vegetation along their shorelines Table 2).

Overall, the majority of AUs (35 AUs; 52 percent) were rated as having low-quality riparian vegetation, 24 AUs (36 percent) had moderate-quality riparian vegetation, and 8 AUs (12 percent) had high-quality riparian conditions (Figures 7 through 11). Table 3 lists commonly observed plant species. AUs with low-quality riparian vegetation were commonly dominated by reed canarygrass and blackberry, with occasional patches of knotweed. Dogwood and willow shrubs were only widely scattered in these low-quality areas but more abundant in riparian vegetation considered to be moderate in quality. Moderate-quality areas often also had occasional Oregon ash, black cottonwood, red alder, or big-leaf maples, along with numerous non-native trees, primarily in planted ornamental areas. High-quality vegetation in the study area was usually dominated by mature cottonwood, alder, and/or maples but occasionally included wild cherry and Douglas fir. The understory, even in areas rated as having high-quality riparian vegetation, was almost always dominated by blackberries or reed canarygrass. Seven of the high-quality AUs were found in EMU 3 (Figure 9), one in EMU 4 (Figure 10), and two in EMU 5 (Figure 11).

Only three AUs, one in EMU 3 and two in EMU 5, had marsh vegetation greater than 10 feet wide over 50 percent of the shoreline; all other AUs had little or no marsh vegetation. Just two AUs (3.08, 4.08) were rated as providing sources for LWD recruitment to the river, although many other AUs had one or more relatively large trees (e.g., 1-foot diameter at breast height or greater) that, if they fell into the river, would provide a source of cover for small fish. A majority (52 AUs; 78 percent) of AUs had little or no LWD, and of the remaining 15 AUs, 10 had low densities of wood (0.2 pieces/30 meters of shoreline), 2 had somewhat higher densities (0.5 pieces/30 meters of shoreline), and only 3 had 1.0 piece/30 meters of shoreline. Most pieces of LWD were either large very old logs partially embedded in the riverbed or smaller, deciduous trees along the banks, most of which likely had fallen, more or less, in place.

EMU Descriptions

EMU 1 Lower Green River (RM 17 to RM 16)

EMU 1 includes the southern (upstream-most) portion of the Green River within Tukwila's city limits, extending from approximately RM 17.3 to RM 16 (Figure 2). The river here is entirely fresh water, and adjacent land use is predominantly light industrial/commercial with recreational uses (Briscoe Park) on the right bank and agriculture on the left bank. EMU 1 has seven AUs; six have low-quality riparian vegetation consisting primarily of blackberries and scattered patches of reed canarygrass and Japanese knotweed (Photo 1 and Figure 7). We observed a moderate amount of LWD in the channel, in comparison with other EMUs; in part, this is a remnant of the historic O'Brian log jam that once occupied this area (A. Levesque, King County, personal communication). Because of the agricultural land use along the left bank of this EMU (Figure 7), there is a high potential for habitat restoration here, with restoration opportunities in six of the seven AUs (Table 5 and Figure 12). Restoration opportunities could include building side-channel or off-channel habitat, or creating a bench feature with enhanced riparian vegetation. A small culverted creek enters AU 1.3 through a culvert (Photo 2) and possibly could be daylighted in conjunction with one of the restoration actions. See the Restoration Opportunities section for a complete discussion.

EMU 2 Lower Green River (RM 16 to RM 12.5)

EMU 2 extends from approximately RM 16 to RM 12.5, at the I-405 bridges, and is the lowest totally freshwater portion of the Green River (Figure 3). Freshwater sources include the stormwater pond near the South Center shopping areas and the culvert outflow of Gilliam Creek just above I-405. Adjacent land use on the right bank is mostly road (West Valley Highway) while the left bank is occupied by a bike path and industrial/commercial areas.

EMU 2 has 13 AUs; 6 have low-quality riparian vegetation and 7 have moderate; consisting primarily of willow, blackberry, Japanese knotweed, scattered patches of reed canarygrass, and a variety of trees situated mostly away from the shoreline: black cottonwood, big-leaf maple, and numerous ornamental trees (Photo 3 and Figure 8). The majority of the shoreline is riprapped or bulkheaded and several bridges cross the river. Two recent restoration projects involving bench construction, riparian enhancement, and instream LWD are present in AUs 2.01B and 2.02B (Photo 4). Additional restoration opportunities, mostly dike setbacks, bench construction, and vegetation enhancements, were identified in eight additional Aus (Table 5 and Figure 13). In one AU (2.9) there is a potential for construction of a river side-channel through an existing City park.

EMU 3 Upper Duwamish Estuary (I-405 to I-5)

EMU 3 extends from RM 12.5 at the I-405 bridges to RM 9 at the I-5 bridge and is the beginning of the Duwamish estuary, as tidal influence extends to roughly RM 12 (Figure 4). The most notable freshwater source in EMU 3 is the Black River, at RM 11. Adjacent land use on both sides is mostly recreational (e.g., as Fort Dent Park and the Foster Golf Course), with some industrial/commercial areas (Figure 9).

As a result of this mix of land use, the condition of the riparian vegetation in this EMU is relatively good (e.g., Photos 5 and 6). EMU 3 has 20 AUs; 4 have low-quality riparian conditions, 10 have moderate, and 6 have high-quality vegetation (Figure 9). Riparian vegetation consists primarily of some patches of reed canarygrass with blackberry, dogwood, willow, and Japanese knotweed as the primary shrubs. Trees include red alder, big-leaf maple, ash, black cottonwood, and numerous non-native trees; trees in this EMU are generally situated closer to the shoreline than in EMU 2. One area of steel sheet-pile bulkhead was found at about RM 9.3 (AU 3.15; Photo 7). Several restoration projects, mostly riparian enhancements, have been completed in this EMU. We identified six additional opportunities for off-channel and side-channel creation or enhancement and for riparian vegetation enhancement (Table 5 and Figure 14).

EMU 4 Middle Duwamish Estuary (I-5 to East Marginal Way South)

EMU 4 extends from RM 9 at the I-5 bridge to RM 7 (Figure 5). The river in this reach has only narrow riparian buffers, constrained by streets and residential properties in Allentown (Photo 8). EMU 4 has eight assessment units; four with low-quality riparian conditions, three with moderate and one with high (Figure 10). Vegetation generally consisted of an understory of willows, blackberry, and Japanese knotweed, with scattered patches of snowberries; fairly abundant big-leaf maple, black cottonwood, and non-native trees are also grouped along the shoreline. We identified two restoration opportunities (Figure 15): One is the Codega Farms (Photo 9) off-channel habitat project and the other would improve riparian conditions in low-quality vegetation areas.

EMU 5 Lower Duwamish Estuary

EMU 5 begins at RM 7 at the East Marginal Way Bridge and extends to the city limits below RM 4 (Figure 6). Adjacent land use is predominantly industrial/commercial. The riparian buffer is slim to none and the downstream portion of the EMU has extensive overwater structures (e.g., Photo 10). However some sand- and mudflats are present, and two small freshwater streams enter along the left bank (Hamm Creek, Riverton Creek). EMU 5 has 19 assessment units, most (15) with little if any riparian vegetation, 3 with moderate, and 1 with high-quality vegetation (Figure 11). Where it exists, vegetation consists primarily of dogwood, willow, snowberry, blackberries and scattered patches of reed canarygrass, and Japanese knotweed. Although mostly non-native trees are present in this EMU, some black cottonwoods, birch, cherry, big-leaf maple, and ash trees are scattered about. The high-scoring AU (5.07 in the “Boeing oxbow” reach at RM 6; Photo 11) has dense clusters of native trees on the shoreline and extending landward up to 200 feet in places. AU 5.11, has moderate-quality vegetation because of the Coastal America restoration sites adjacent to the Turning Basin. Riparian conditions can be expected to continue to improve over time. We identified several additional restoration opportunities in low- to moderate-quality habitats (Table 5 and Figure 16).

RESTORATION OPPORTUNITIES

General

The ultimate goals of estuary and riverine restoration are to preserve remaining natural ecosystem components and processes, and to restore and enhance, to the extent practicable, those processes that have been lost or degraded to promote the recovery of listed salmonids. Increasing the area and quality of habitats in the Green/Duwamish River within the City of Tukwila will replace critical lower river and estuarine habitat that has been lost to development over the last 150 years. Replacement of as much as practicable of the in-channel, off-channel, and riparian habitats will maximize the chances that native salmonid populations can achieve the abundance, geographic distribution, and life history diversity to be self-sustaining and productive into the future.

In the upper reaches of shorelines within the City of Tukwila (EMUs 1 and 2), restoration opportunities are constrained by the flood control requirements of the levee system and by intensive adjacent land uses. Flood control requirements limit the size and location where trees can be grown on the dikes; nevertheless, widespread opportunities to enhance the existing mostly non-native riparian scrub-shrub vegetation with native species such as willows that provide greater riparian function and can be maintained to meet the dike integrity needs. There are limited locations where dikes can be set back from the river, or removed altogether, thus allowing more robust riparian vegetation to develop.

Due to the heavily altered channel conditions, constraints of adjacent land uses, and extent of armored shoreline in the Duwamish estuary, the restoration opportunities most beneficial to fish would create or expand existing side-channel or off-channel habitat to provide protected, productive rearing areas in the portion of the river where juvenile salmonids are adapting physiologically to increasing salinities (e.g., in EMUs 4 and 5). Side-channel habitats are assumed to be those that provide an alternate path of flow for the river (i.e., they are connected to the river at two locations); off-channel habitats are only connected to the river at one location and are intended to mimic blind sloughs, common in natural systems. Another type of restoration that is applicable to more areas of the lower estuary is to provide or improve shallow habitat along the banks of the mainstem, namely through the addition of LWD, recontouring to allow marsh development, and through enhancement of riparian vegetation.

We identified 30 potential restoration sites in the Green/Duwamish within Tukwila's city limits; individual site plans and actions are subjectively ranked and described in Tables 4 and 5. These sites do not represent the entire suite of sites where restoration could occur, nor do they imply an acceptance by the present landowner of that use. Levee setback is assumed to include some level of benching to achieve desired elevations as well as riparian enhancement (e.g., Photo 12). Benching is assumed to include planting and maintenance of native riparian vegetation, typically including large tree species. Small-scale riparian enhancements, in the form of control of non-native invasive species and replacement with native plants, could occur and should be encouraged almost everywhere along the City's shorelines. These opportunities are not specifically identified except where they could encompass large reaches of shoreline or where riverbank morphology would appear to allow planting of potentially large trees without compromising flood control requirements of levees or revetments.

Ranking (Table 5) was subjectively based first on the area of potential new aquatic habitat that could be provided, second on the length of existing habitat that could be enhanced, and third on the technical difficulty or cost of acquisition and construction. More quantitative ranking based on ecological functions that could be provided, new or enhanced habitat area, position in the ecological landscape, and cost could be accomplished (outside the present scope) using the approach described for the Snohomish estuary by the City of Everett and Pentec (2001).

EMU 1

Restoration opportunities exist in five out of seven AUs in EMU 1 (Figure 12): three side-channel and two bench construction projects (Tables 4 and 5). EMU 1 currently has low-quality riparian conditions and could benefit significantly from these opportunities. AU 1.05 has the highest restoration potential of any site evaluated in terms of potential area of side-channel or off-channel habitat that could be created (Photo 13). Project would involve site purchase and would target construction of a side-channel with extensive wetland habitat. In addition to considerable site purchase cost, river degradation in this reach would require considerable soil removal to attain appropriate elevations for off-channel habitat. AU 1.08 contains Briscoe Park, and could accommodate a side channel through the middle of the park. Bridging of the channel would be required to retain the majority of park area and access to the existing river edge.

EMU 2

We observed a number of restoration projects underway, in the form of side-channel refuge habitat and extensive willow plantings. Notable sites were observed in AU 2.02B (Desimone Levee), where King County set back a levee, constructed a bench, and planted willows and numerous other native riparian plants on the bench and adjacent slopes (Photos 4 and 12). Across the river, in AU 2.01B (the Segale Levee), large boulders were placed and LWD was attached to create in-channel refugia for juvenile salmonids. In AU 2.06, King County has done another levee setback and built a bench with some riparian plantings.

Restoration opportunities exist in eight out of thirteen AUs in EMU 2 (Figure 13): one side-channel and one off-channel habitat area, two bench opportunities, two levee setbacks, and three riparian enhancement projects. Side-channel habitat could be created at about RM 12.9 in an existing city park at Nelson Landing.

Such a project would require excavation though blackberries in a former channel at the south edge of the park, along the base of a higher terrace supporting the bike trail and commercial/residential development. A foot bridge would be required to access the park. Off-channel habitat could be gained by connecting an existing wetland on vacant land just upstream of I-405 at the south end of AU 2.10. Average riparian conditions throughout the AUs are moderate but most of the area is dominated by non-native species. The three riparian enhancement opportunities are for long stretches of blackberry bushes that could be replaced with native vegetation (e.g., Photo 3).

EMU 3

Restoration opportunities exist in five out of twenty AUs in EMU 3 (two in AU 3.10) (Figure 14): four off-channel and two riparian enhancement projects. Two of the potential off-channel habitat construction areas are in parcels of land between major arterials; considerable excavation would be required and access could be problematic (Photo 14). The third off-channel habitat project would simply enhance, by deepening, an existing off-channel project at RM 12 (Photo 15) that was constructed as mitigation for adjacent development. An opportunity exists to excavate a large side channel across vacant land on the west margin of Fort Dent Park to shortcut the existing sharp bend (Photo 16). This project would require two bridges to maintain the existing bike trail; alternatively, a new trail could be built leaving an inaccessible "wild" island in midstream. This would allow natural river processes to shape the area between the new and existing channel. Average riparian conditions throughout the EMU are moderate, and two of the riparian enhancement opportunities are in AUs with low-quality riparian condition; the third is along the west edge of Fort Dent Park along the existing bike trail, and near the mouth of the Black River in low-quality portions of AU 3.10.

EMU 4

Restoration opportunities exist in two out of eight AUs in EMU 4 (Figure 15): one side-channel and one riparian enhancement project. Average riparian vegetation conditions throughout the EMU are moderate, and both restoration opportunities are in AUs that currently have low riparian quality. AU 4.04 contains Codega Farms, a site that has been previously identified as a prime restoration opportunity which is close to implementation (Photo 9). This site offers an excellent opportunity to construct off-channel habitat for salmonids to complement the existing shallow-water habitat provided by the sand bar adjacent to the site. AU 4.01 immediately below I-5 has a wide riparian zone (approximately 75 feet), dominated by blackberries that could be replaced with native vegetation.

EMU 5

A number of groups have been active in identifying restoration opportunities and several projects have already been implemented. In the lower part of the estuary (EMU 5 and downstream), active organizations include the following: Port of Seattle, City of Seattle, King County, People for Puget Sound, U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, The Boeing Company, and the City of Tukwila. Two major marsh and side-channel restoration projects have been constructed in AU 5.11, called Turning Basin and Kenco Marine (also known as Coastal America sites I and II). A derelict vessel was removed and a variety of native marsh and riparian plantings have been very successful at returning the left bank in the Turning Basin site into productive littoral habitat. Also, in AUs 5.08 and 5.07, the City of Tukwila and The Boeing Company (Photo 16), respectively, have incorporated LWD and successful riparian plantings into needed repairs of riprap protecting failed revetments.

Additional restoration opportunities exist in eight out of nineteen AUs in EMU 5 (Figure 16); six of these are levee setback or shoreline bench projects (Table 5). The remaining two are major off-channel habitat creation projects on either side of the river at about RM 6.3 (Tanner 1991, Sites 1 and 2). Both of these are currently in the funding and planning stages.

CONSERVATION OPPORTUNITIES

Despite the highly modified nature of the Green/Duwamish River channel and adjacent riparian areas within the shorelines of Tukwila, many areas within these reaches offer good to excellent habitat for a variety of ecological functions, including migration, feeding, and osmoregulatory adjustment by salmonids (both juveniles and adults). For the most part these areas are well protected by local (SMP) and state Hydraulic Code (WAC 220-110) regulations regarding construction below OHW. These include areas such as the sand- and mudflats that are exposed or partially exposed at low tide which are found in several AUs, particularly on the inside of river bends in EMUs 4 and 5, beginning at Codega Farms (RM 8.6, AU 4.04; Photo 9). Additional areas with exceptionally good littoral habitat include the restored areas on the left bank of the Turning Basin (AU 5.11), the left bank along the Boeing oxbow from about RM 5.5 to 6.2 (AU 5.07; Photo 10), and the right bank, immediately below the Northwind Weir site (RM 6.3, AU 5.06; Photo 17). These areas have a shoreline zonation from low-gradient silty sand or mud to an upper shoreline band of brackish marsh dominated by species such as Lyngbye's sedge (*Carex lyngbyei*), to a reasonably robust riparian zone dominated by native trees and shrubs.

Although no measure was applied in this study to assess ecological functions beyond the qualitative classifications of riparian vegetation conditions, several conservation opportunities can be identified. These opportunities reflect both existing sites with above-average function that should be considered for higher protection than currently offered, and, in at least two cases, sites with high restoration potential that should be considered for protection of that potential.

Certainly, the top-ranked restoration opportunities listed in Table 5 reflect the very limited locations where significant areas of new aquatic habitat can be constructed that are connected to the river and offer juvenile salmonids side-channel and off-channel rearing habitat. These include areas that are currently agricultural fields in AUs 1.01 and 1.05 (Photo 13). Generally, other side-channel or off-channel restoration opportunities identified in Table 5 are on lands that are already in public ownership. Most of the other restoration opportunities listed are inside existing levees, and presumably not available under current regulations for development or alteration that would preclude the restoration actions described.

RECOMMENDATIONS

The inventory reported herein and the data provided offer the City a very detailed accounting of existing shoreline conditions within the city limits and in the South Planning Area. These data should serve as a guide for protection of existing habitat functions within the City and to restoration of those functions where the opportunities exist.

Appropriate Buffer Size and Management of Riparian Zones

Because of the degree of existing modification of the City's shorelines, existing riparian vegetation occurs in relatively narrow bands almost always less than 100 feet and usually less than 50 feet. In many cases, the entire zone of riparian vegetation lies on the riverward slope of a revetment; where a trail or other paved commercial, industrial, or infrastructure area encroaches to the top of a revetment, there is little to protect other than that inner face of the revetment. Usual width of this area is about 50 feet or less from OHW.

Where the riparian zone occupies the riverward and perhaps the landward slope of a dike, the cumulative width to development or agricultural activity on the inside of the dike is less than 100 feet; typically the top of the dike is occupied by a recreational or maintenance trail or road. While tall trees on the landward side of dikes may contribute marginally to shade, leaf litter, or insect fall to the river, other typical ecological functions of riparian zones (sediment and nutrient removal, hydrologic moderation, LWD contribution) are rendered ineffective by the presence of the dike (e.g., Pentec 2002). Thus, there would appear to be little gained by mandating buffer widths in excess of the distance to the landward edge of the top of the dike.

In a few areas within the City, substantial stands of larger trees provide higher-quality riparian vegetation that warrants additional protections. In most cases, these higher-quality riparian stands occur where the riverbank revetment transitions into a relatively flat upland that is in residential or recreational use (i.e., unpaved). These areas should receive higher protection, perhaps in the form of restrictions on cutting of trees above a certain size. In areas where the flood control levees or revetments are pulled back from the river, there are significant stands of trees and shrubs inside the levees that should be protected.

In summary, major concerns for protection or enhancement of existing riparian functions along the Green/Duwamish River within the City of Tukwila would appear to be met with relatively modest buffer-width requirements. These requirements could be tailored to specific shoreline identified in this inventory. As a general rule, we recommend that no native vegetation be cut on the riverward side of the top of bank along all levees and revetments, except as necessary to maintain the flood control function of the levee or revetment, or to provide for public safety or necessary infrastructure.

Restoration

While the previous section suggests that protection of the existing condition of Green/Duwamish River in the City can be achieved through the use of relatively modest buffer requirements, there is much that could be done to enhance the existing riparian zones. As noted in this survey, over half of the AUs in the City were rated as having low-quality riparian vegetation, even by the very generous criteria identified above. Even those AUs that were rated as having moderate- or high-quality riparian vegetation, virtually all had an understory dominated by non-native species. As a result, substantial improvement in the quality of riparian functions provided within the City is possible and (along with any of the other possible restoration projects listed in Table 5) would make a positive contribution toward improvement of conditions for anadromous and resident fish in the City and in the larger Green/Duwamish watershed.

It appears that the City has several potential avenues for initiating or stimulating a trend toward improvement in shoreline conditions within its boundaries:

- Direct funding of restoration actions, perhaps even acting as a mitigation banker: The City could establish a fund from which the City would accomplish restoration actions; then, when developers had a need for a mitigation credit, they could simply pay a commensurate amount into the fund.

- Requiring that restoration actions be undertaken as mitigation for new development or redevelopment within the City's shorelines jurisdiction.

- Making information such as this report available to those parties potentially in need of mitigation credits, or seeking restoration opportunities that will contribute to salmon restoration.

- Initiating education and/or community involvement programs similar to the adopt-a-beach or adopt-a-highway programs wherein a neighborhood, service group, club, industry, or other organization could sign up to take stewardship of a given reach of shoreline. Such groups might even compete in some way to see which could provide the most improved conditions in a given time frame.

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TABLES

Table 1 - Field Inventory Sheet
City of Tukwila

AU #	Bank ______	(L/R facing downstream)
Date	Levee/Dike ______	(floodplain area behind levee is isolated from the river)
Surveyors	Revetment ______	(floodplain area behind revetment is filled)
	Natural ______	(minimal shoreline modification)

	Y/N/C	Codes/Comments
Hydrology		
1 AU has vernal or perennial freshwater stream or spring		
2 AU has refuge from high velocities		
3a AU contains a natural tidal channel wetted at MLLW		
3b AU contains tidal channel wetted at MSL (i.e., shallow drainage)		
4 Tidal channel is dendritic or highly sinuous		
Water Quality		
5a Fresh water only (salinity < 0.5 ppt)		
5b Oligohaline to Mesohaline (sal. variable: often 0.5 to 5 ppt, but can range to 18 ppt)		
Vegetated Edge		
Below OHW		
6a Buffer: marsh edge > 10 ft wide over 50% of shoreline		
6b Marsh edge > 5 ft wide over 50% of shoreline; or > 10 ft wide over 25-50% of shoreline		
6c Marsh edge exists but < 5 ft wide, or less than 25% (but > 5%) of shoreline		
6d Marsh of native species occupies more than 25% of total AU		
Types/Species		
7 Grasses/Sedges		
8 Shrubs (e.g., willows)		
Above OHW (riparian zone)		
9a Riparian scrub-shrub* and/or forested > 25 ft wide over 10 to 24% of shoreline		
9b Riparian scrub-shrub* and/or forested > 25 ft wide over 25 to 50% of shoreline		
9c Riparian scrub-shrub* and/or forested > 25 ft over 50% of shoreline		
10 Riparian vegetation is dominated by native species		
11 Riparian zone provides signif. source of LWD recruitment		
* woody vegetation at least 6 feet in height		

Table 1 - Field Inventory Sheet
City of Tukwila

AU **Date**	Y/N/C	Codes/Comments
Types/Species		
12 Grasses/Sedges		
13 Shrubs		
14 Trees		
Land Use		
15 Adjacent land uses (within the 200-foot shoreline zone, in order of distance)	C	
Large Woody Debris (LWD) density (LWD must be in the IT zone below MHHW)		
16a 1.0 piece/channel width, /30 m of shoreline, or /100 m² of AU whichever is greater		
16b 0.5 piece/channel width, /30 m of shoreline, or /100 m² of AU whichever is greater		
16c 0.2 piece/channel width, /30 m of shoreline, or /100 m² of AU whichever is greater		
Stressors		
17a Immigration/emigration restricted 25 to 50% of the time		
17b Immigration/emigration restricted 50 to 75% of the time		
17c Immigration/emigration restricted 75 to 90% of the time		
18a Riprap or vertical bulkheads extend below MHHW for 10 - 50% of shore		
18b Riprap or vertical bulkheads extend below MHHW along > 50% of shore		
19 Majority of riprapped or bulkheaded shoreline extends below MSL (+6 ft MLLW)		
20 Armoring/Substrate (below OHW)	C	
21 Armoring/Substrate (above OHW)	C	
22a Bridge, finger pier, or dock > 8 ft wide		
22b Two or more bridges, finger piers, or docks > 8 ft wide; or single structure > 25 ft wide		
23a Overwater structures cover 10 to 30% of littoral area in AU		
23b Overwater structures cover 30 to 50% of littoral area in AU		
23c Overwater structures cover 50 to 75% of littoral area in AU		
23d Overwater structures cover > 75% of littoral area in AU		
24 Littoral benthic habitat routinely disturbed by prop wash, chronic oil spills, or dredging		

Table 2 - Percent of AUs Containing Different Levels of Riparian Vegetation

Riparian Zone Greater Than 25 Feet Over	Percent of Total AUs
Less than 10% of shoreline; or, no significant riparian vegetation	16
10-24% of shoreline	3
25-50% of shoreline	7
51-100% of shoreline	72

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Table 3 - Commonly Observed Riparian Plant Species

Type	Common Name	Scientific Name	Field Code	Native
Grasses	Reed canarygrass	*Phalaris arundinacea*	R-cng	No
Shrubs	Blackberry	*Rubus* spp.	Bber	No
Shrubs	Japanese knotweed	*Polygonum cuspidatum*	Knot	No
Shrubs	Willow	*Salix* spp.	Will	
Shrubs	Red-osier dogwood	*Cornus stolonifera*	Dog	
Shrubs	Snowberry	*Symphoricarpos albus*	SnoB	
Trees	Oregon Ash	*Fraxinus latifolia*	Ash, Oash	
Trees	Red alder	*Alnus rubra*	Ald	
Trees	Black cottonwood	*Populus balsamifera*	Cottn	
Trees	Big-leaf maple	*Acer macrophyllum*	Blmap	
Trees	Bitter cherry	*Prunus emarginata*	Cher	
Trees	Douglas fir	*Pseudotsuga menziesii*	Dfir	
Trees	Numerous non-natives			No

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Table 4 - Summary of Restoration Opportunities by Type and EMU

			Restoration Opportunities					
EMU	**Average Riparian Quality**	**Number of AUs**	**Side-/Off-Channel**	**Levee Setback**	**Bench**	**Riparian Enhancement***	**Number of Restoration Opportunities**	**% AUs with Restoration Potential**
1	Low	7	3		2		5	71%
2	Moderate	13	2	2	2	3	9	62%
3	Moderate	20	4			2	6	20%
4	Moderate	8	1			1	2	25%
5	Low	19		2			2	42%
						Total Restoration Opportunities	30	40%

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* Small-scale riparian enhancement in the form of control of non-native invasive species and replacement with native plants could occur almost everywhere along the City's shorelines. Riparian enhancement would also accompany all other project types.

AUs 2.10 and 3.08 each have two restoration opportunities: side-channel and riparian enhancement in different locations.

Table 5 - Ranked Restoration Opportunities

Rank	River Mile	AU Number	Restoration Type	Increased/Enhanced Habitat	Brief Description
13	16.8	1.01	Side channel	3.88 acres	Bench construction OR side-channel construction through existing corn field with vegetation/marsh enhancements.
19	16.6	1.03	Bench	0.3 miles	Bench construction.
18	16.7	1.04	Bench	0.3 miles	Bench construction. Also open grassy field for sale along the river; could dike field and open interior as off-channel habitat.
1	16.0 to 16.5	1.05	Side channel	39.9 acres	Highest restoration potential: large (~39 acre +) agricultural property conducive to constructing large-scale side-channel system with extensive vegetation/marsh enhancements and instream LWD.
7	15.9 to 16.1	1.08	Side channel	2.2 acres	Briscoe Park was built in front of a levee, to create a side channel with increased wetland habitat; could dig a channel through the park, and construct a foot bridge to the existing mainstem bank to retain park features.
14	14.8	2.01C	Levee setback	0.4 miles	Potential bench construction with levee setback just downstream of foot bridge; includes cutting into parking lot.
4	13.9 to 14.1	2.03	Side channel/ off channel	4.6 acres	Stormwater pond has fish access? Create side channel into and out of excellent marsh habitat in pond and build dikes to protect commercial properties; evaluate riverine connection and elevation for possible side habitat at higher tides/floods; existing ecological function is high.
20	15.0	2.04	Bench/sand bar	0.2 miles	Low bench construction just upstream of the foot bridge could create sand bar and enhance riparian zone. Existing vegetation on the broad bank is knotweed and blackberries.
28	13.6	2.05	Riparian enhancement	0.3 miles	Riparian enhancement on revetment.
27	13.7 to 14.6	2.06	Riparian enhancement	0.5 miles	Riparian enhancement including tree plantings along extensive but generally narrow blackberry-dominated riparian. (Two separate sections for possible enhancements.)
21	13.6	2.08	Bench	0.2 miles	Bench construction on the wide bank upstream of the railroad trestle; possible levee setback.
11	12.9	2.09	Side channel	0.7 acres	Build side channel between structures and the river, through dense blackberries; foot bridge would be required to access park.
15	12.8	2.10	Levee setback/possible off-channel habitat	0.1 miles	Vacant lot with historic house just upstream of I-405 bridge—opportunity to construct bench with a levee setback; possibly could connect existing wetland to river as off-channel habitat.
29	12.8	2.10	Riparian enhancement	0.1 miles	Extensive blackberries upstream from I-405 past sand bar.
9	12.6	3.02	Off channel	0.9 acres	Between I-405 and South Center Blvd., opportunity to excavate off-channel habitat.

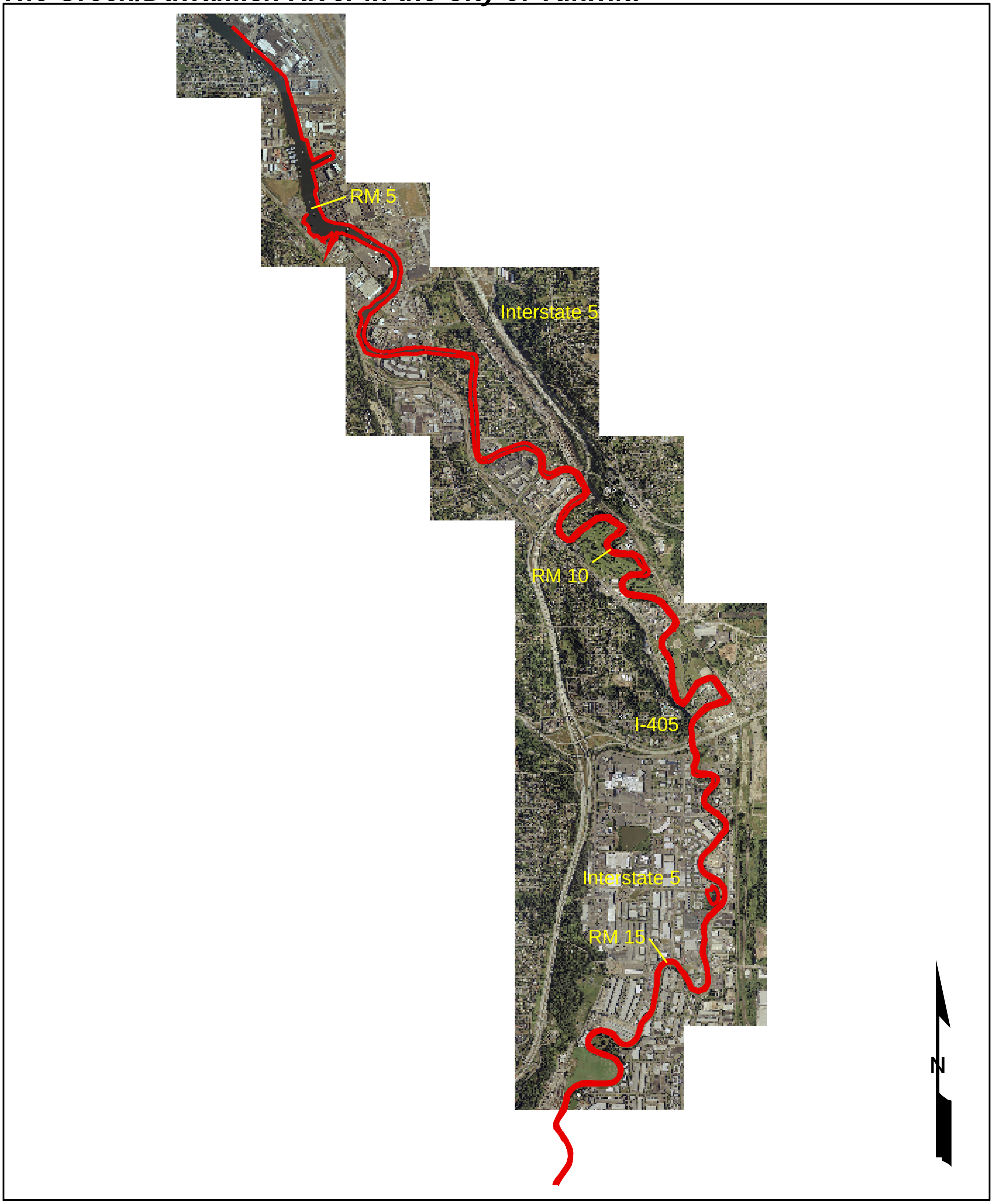
Table 5 - Ranked Restoration Opportunities

Rank	River Mile	AU Number	Restoration Type	Increased/Enhanced Habitat	Brief Description
10	12.5	3.02	Off channel	0.8 acres	Between South Center Blvd. and Interurban, opportunity to excavate off-channel habitat.
12	12.0	3.04	Off channel	0.03 acres	To enhance ongoing restoration enhancement project, lower elevation to create low water access to existing off-channel habitat area.
2	11.4 to 11.6	3.08	Side channel	6.9 acres	Excavate a large side channel across vacant land on west margin of Fort Dent Park; would require two bridges to maintain existing trail or new trail, leaving “wild” island in midstream.
26	11.1 to 11.7	3.08	Riparian enhancement	0.6 miles	Enhance riparian vegetation in the lower portion of the shoreline of Fort Dent Park; remove non-natives and nurture native species, including trees.
30	9.6	3.22	Riparian enhancement	0.1 miles	Riparian enhancement: large blackberry patch at AU boundary by 3.20; remove and plant willows.
25	8.3 to 8.9	4.01	Riparian enhancement	0.6 miles	Riparian enhancement: 75 feet of blackberry bushes; remove and plant willows.
6	8.6	4.04	Side channel	2.4 acres	Major side-channel restoration opportunity at Codega Farms. This project is moving forward under City of Tukwila direction.
8	6.4	5.05	Off channel	1.4 acres	This site (Tanner 1991, Site 2) is being pursued by King County
5	6.4	5.06	Off channel	2.6 acres	This site (Tanner 1991, Site 1) has been purchased for off-channel habitat construction by a consortium of agencies, organizations, and The Boeing Company.
16	5.8	5.09	Levee setback	0.1 miles	Levee setback into mostly vacant parking lot with marsh enhancements. A historic wetland is under the lot with a freshwater outflow. Cattails are already established along the stepped bank.
17	5.6	5.10	Levee setback	0.1 miles	Levee setback into the Boeing parking lot, riparian enhancement and removal of derelict barge.
3	4.7	5.16	Bench/off channel	6.0 acres	Excavate uplands to expand channel along south margin of Slip 6 and into river.
22	4.0	5.20	Bench/riparian enhancement	<1 acre	Shoreline layback and/or riparian enhancements may be possible in conjunction with site remediation.
23	3.9	5.22	Bench/riparian enhancement	<1 acre	Shoreline layback and/or riparian enhancements may be possible in conjunction with site remediation.
24	3.8	5.24	Bench/riparian enhancement	<1 acre	Shoreline layback and/or riparian enhancements may be possible in conjunction with site remediation.

Note: Grayed-out opportunities have been identified by other parties.

FIGURES

The Green/Duwamish River in the City of Tukwila



PENTEC ENVIRONMENTAL

12578-02 ***12/02***

Figure 1

EMU 1 and AU Boundaries

PENTEC ENVIRONMENTAL

12578-02 ***12/02***

Figure 2

EMU 2 and AU Boundaries

PENTEC ENVIRONMENTAL

12578-02

12/02

Figure 3

EMU 3 and AU Boundaries

PENTEC ENVIRONMENTAL

12578-02 ***12/02***

Figure 4

EMU 4 and AU Boundaries

PENTEC ENVIRONMENTAL

12578-02 **12/02**

Figure 5

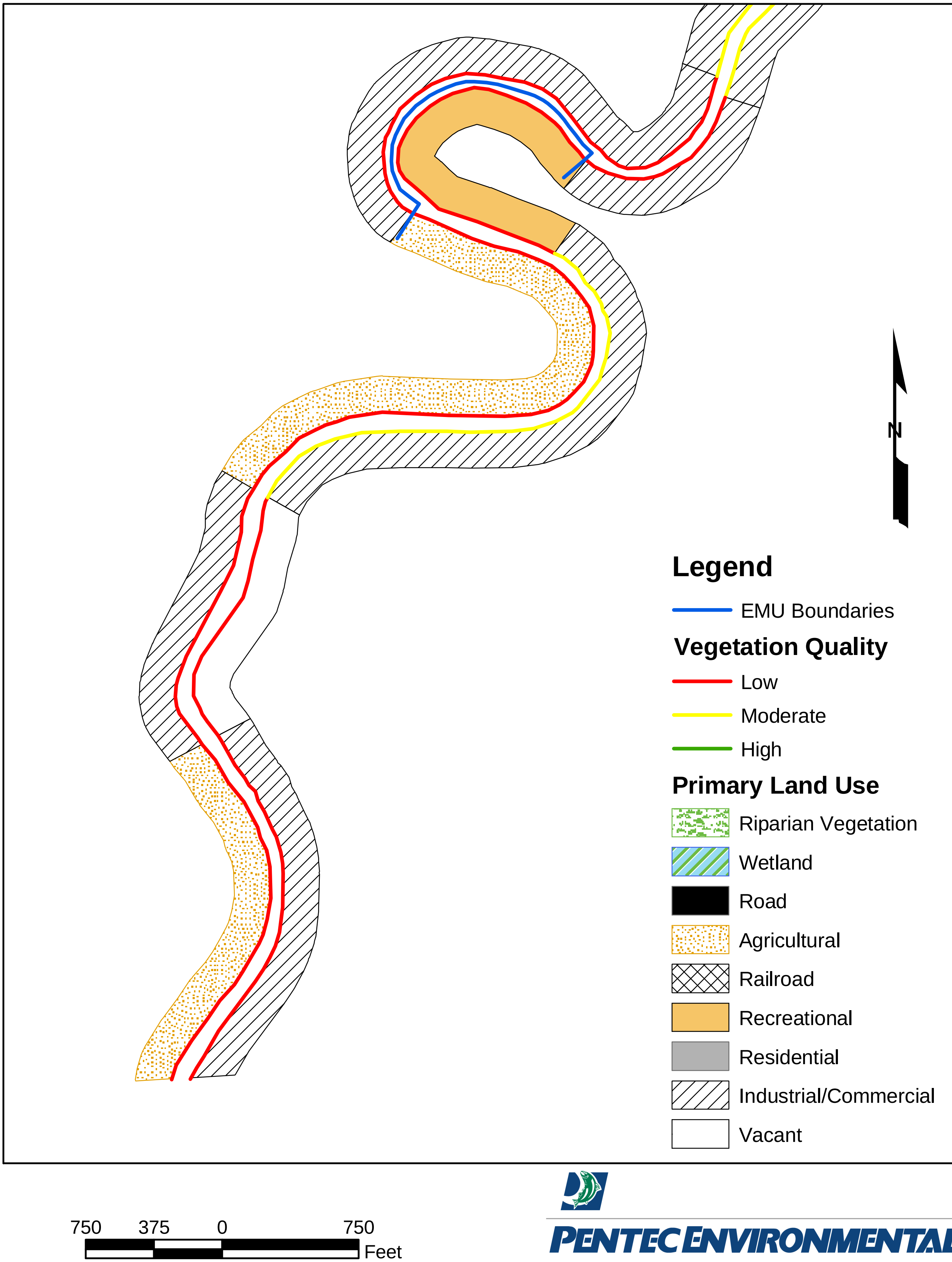
EMU 5 and AU Boundaries

PENTEC ENVIRONMENTAL

12578-02 *12/02*

Figure 6

EMU 1 Existing Riparian Conditions and Land Use



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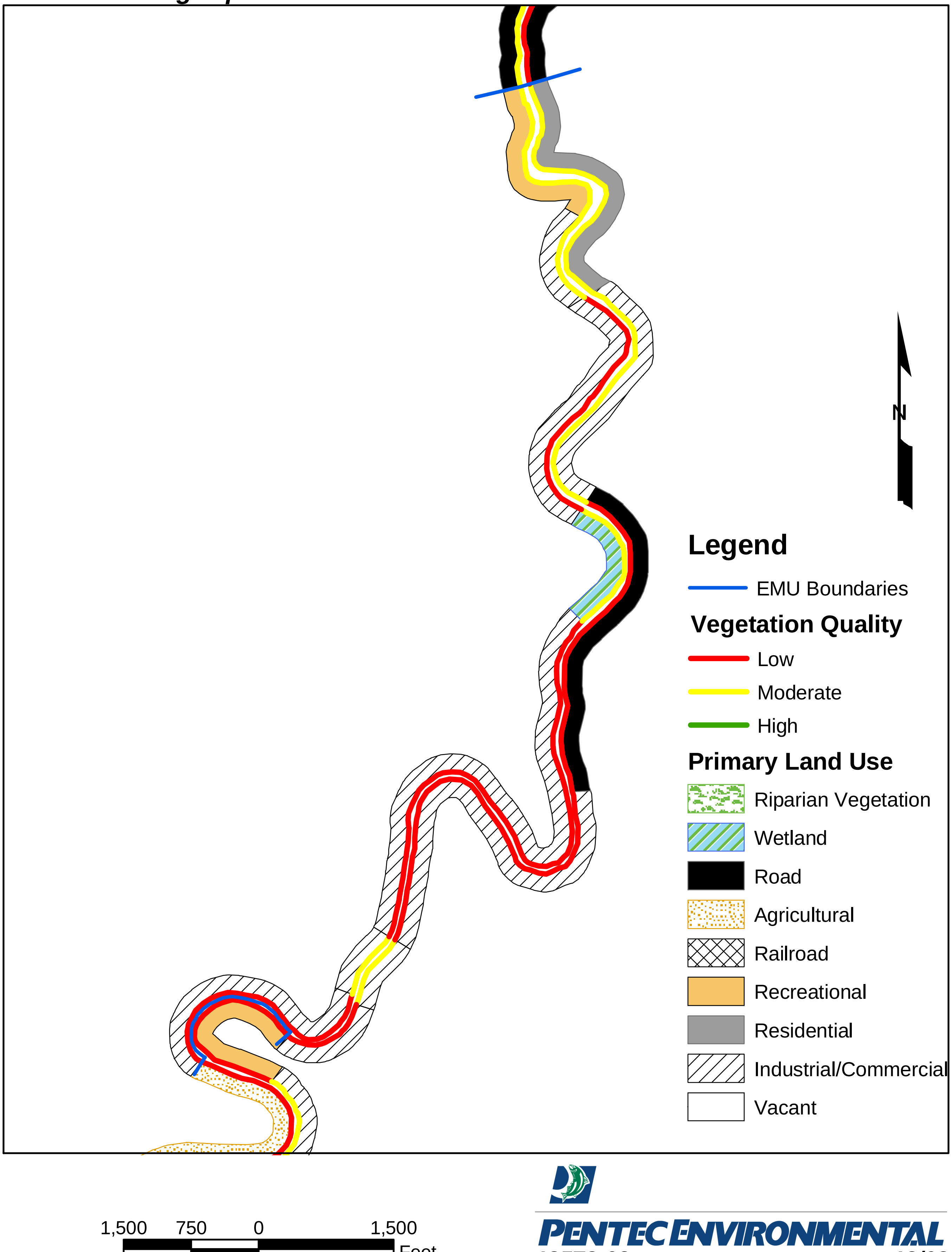
12578-02 *12/02*

Figure 7

EMU 2 Existing Riparian Conditions and Land Use



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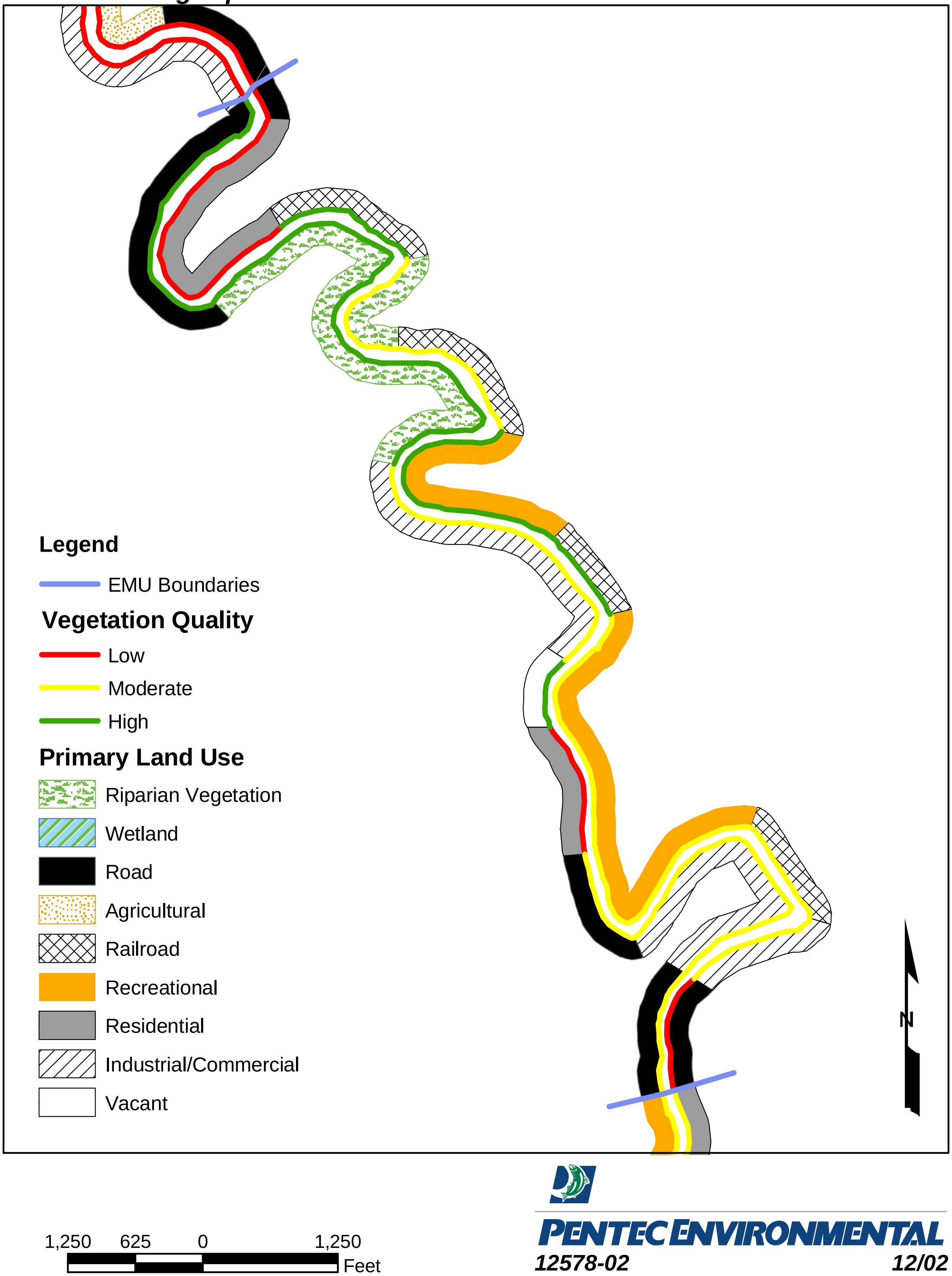
12578-02 ***12/02***

Figure 8

EMU 3 Existing Riparian Conditions and Land Use



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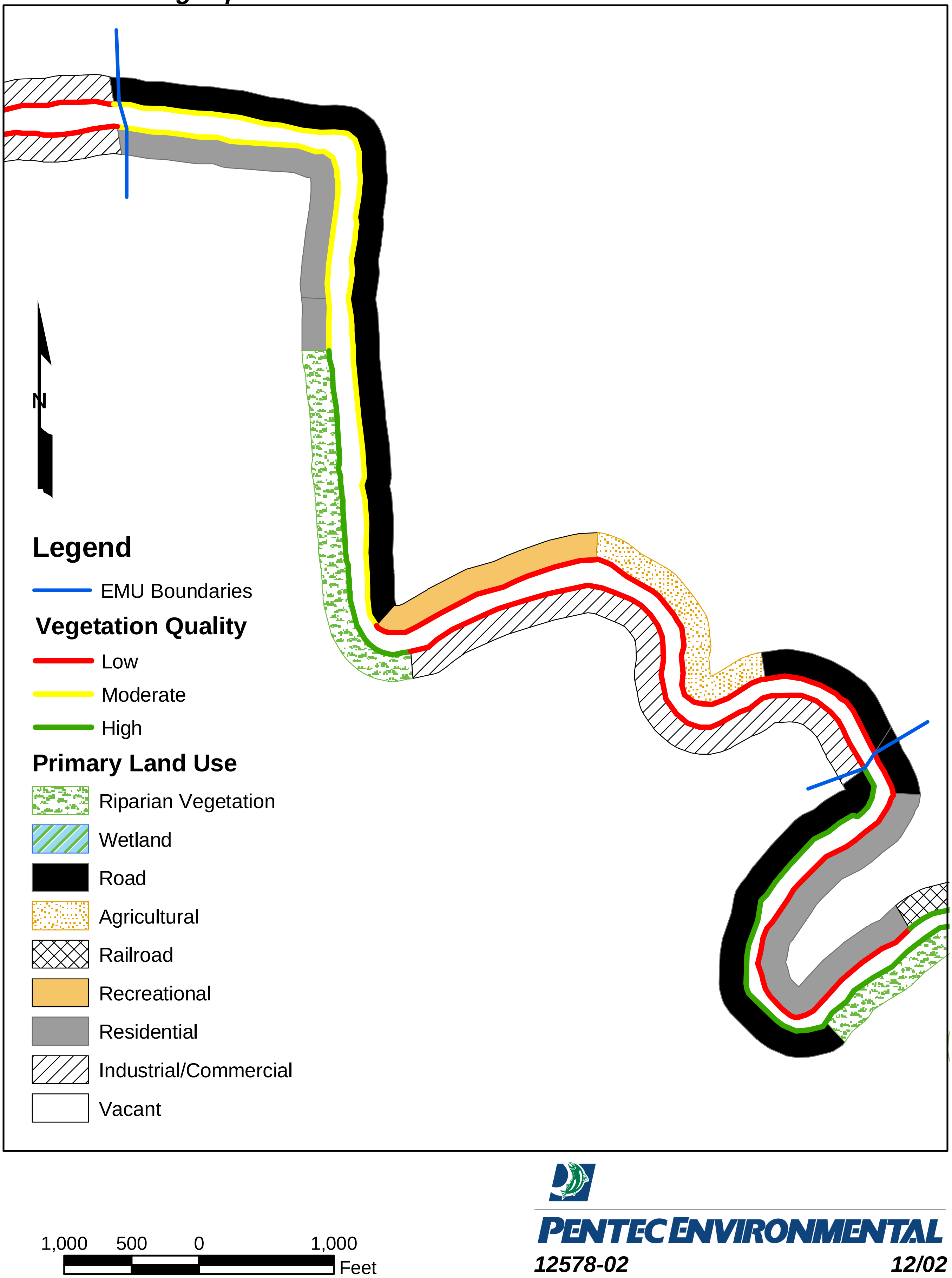
12578-02 ***12/02***

Figure 9

EMU 4 Existing Riparian Conditions and Land Use



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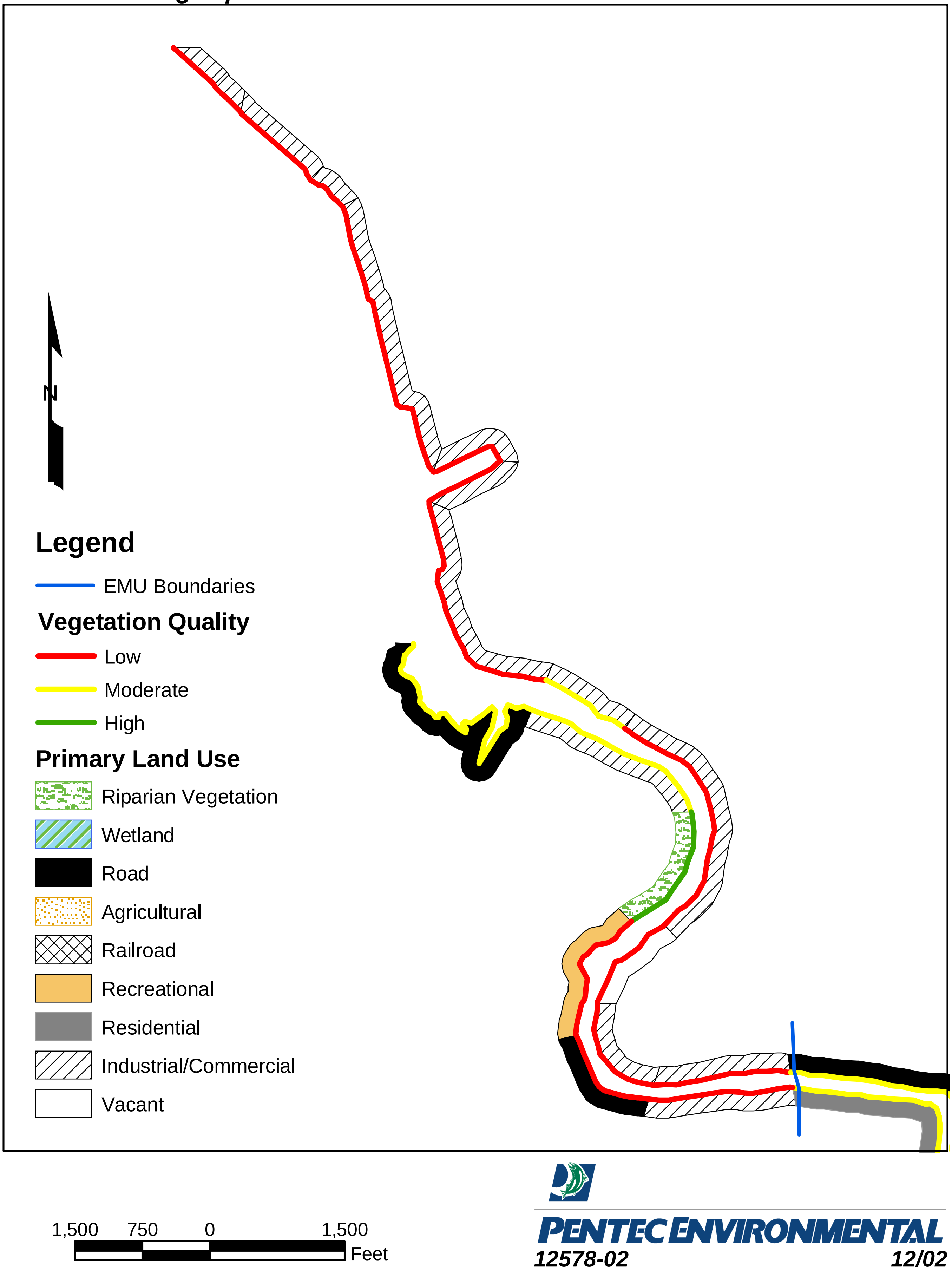
12578-02 12/02

Figure 10

EMU 5 Existing Riparian Conditions and Land Use



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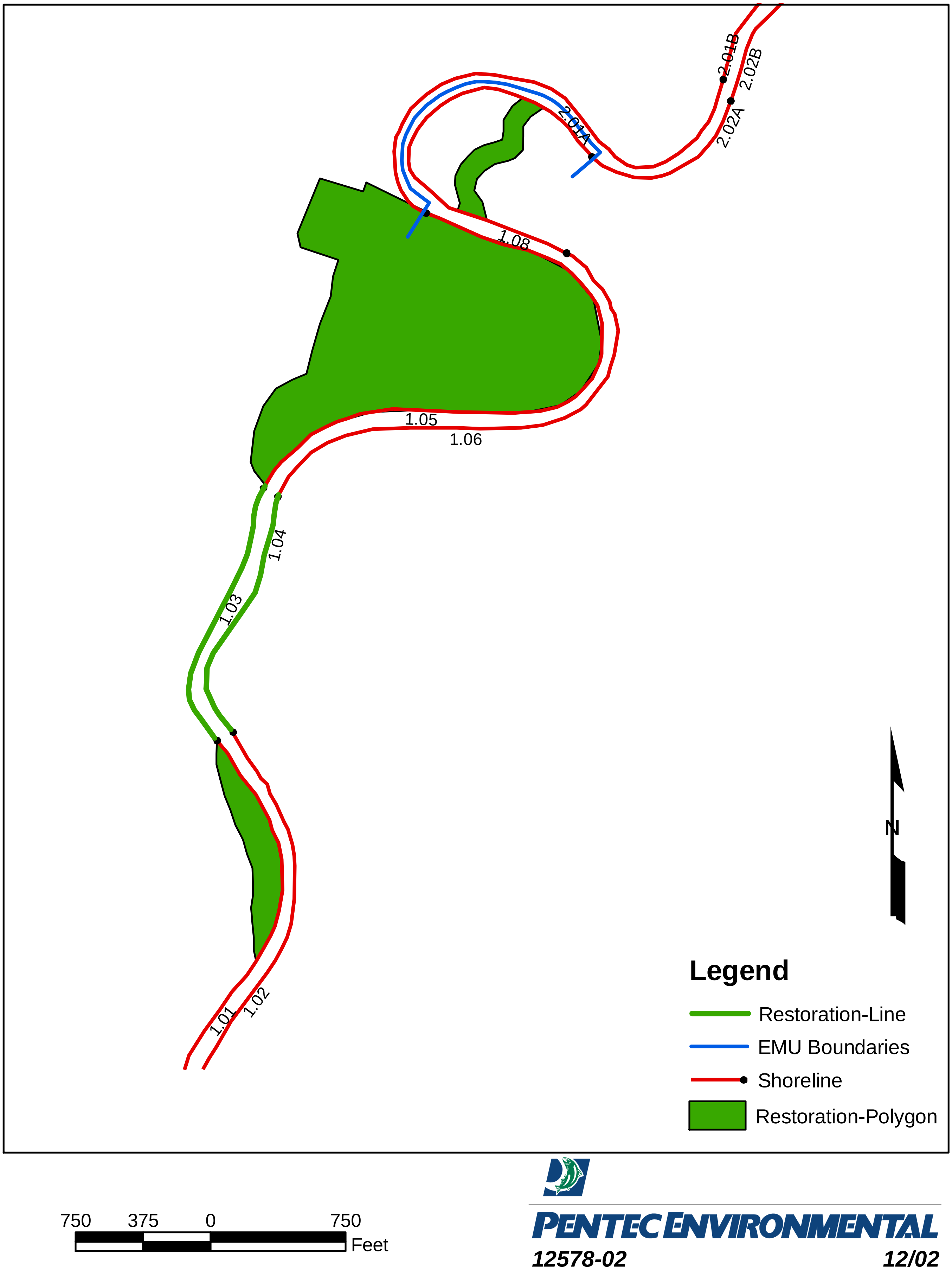
12578-02 ***12/02***

Figure 11

EMU 1 Restoration Opportunities



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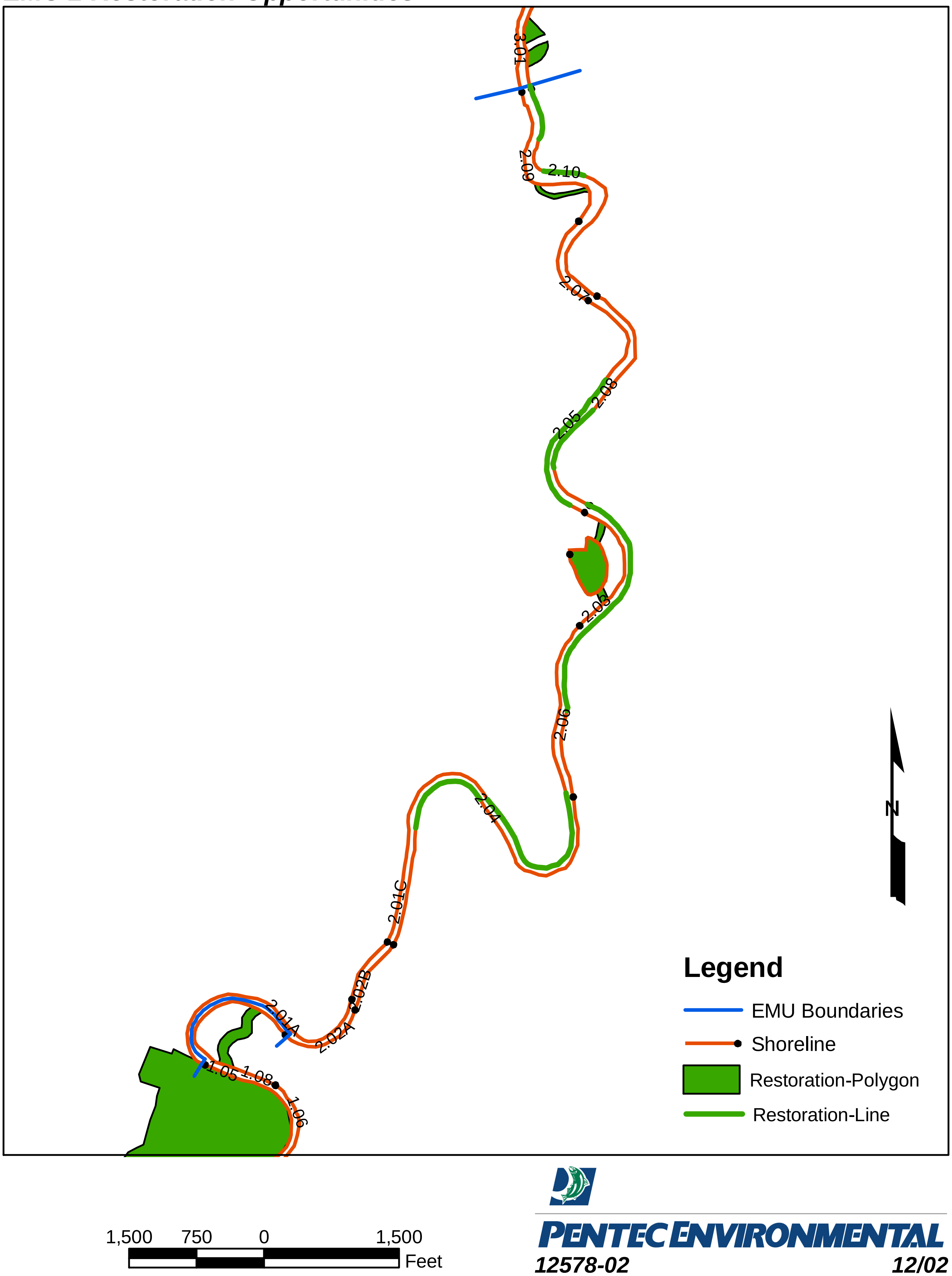
12578-02 ***12/02***

Figure 12

EMU 2 Restoration Opportunities



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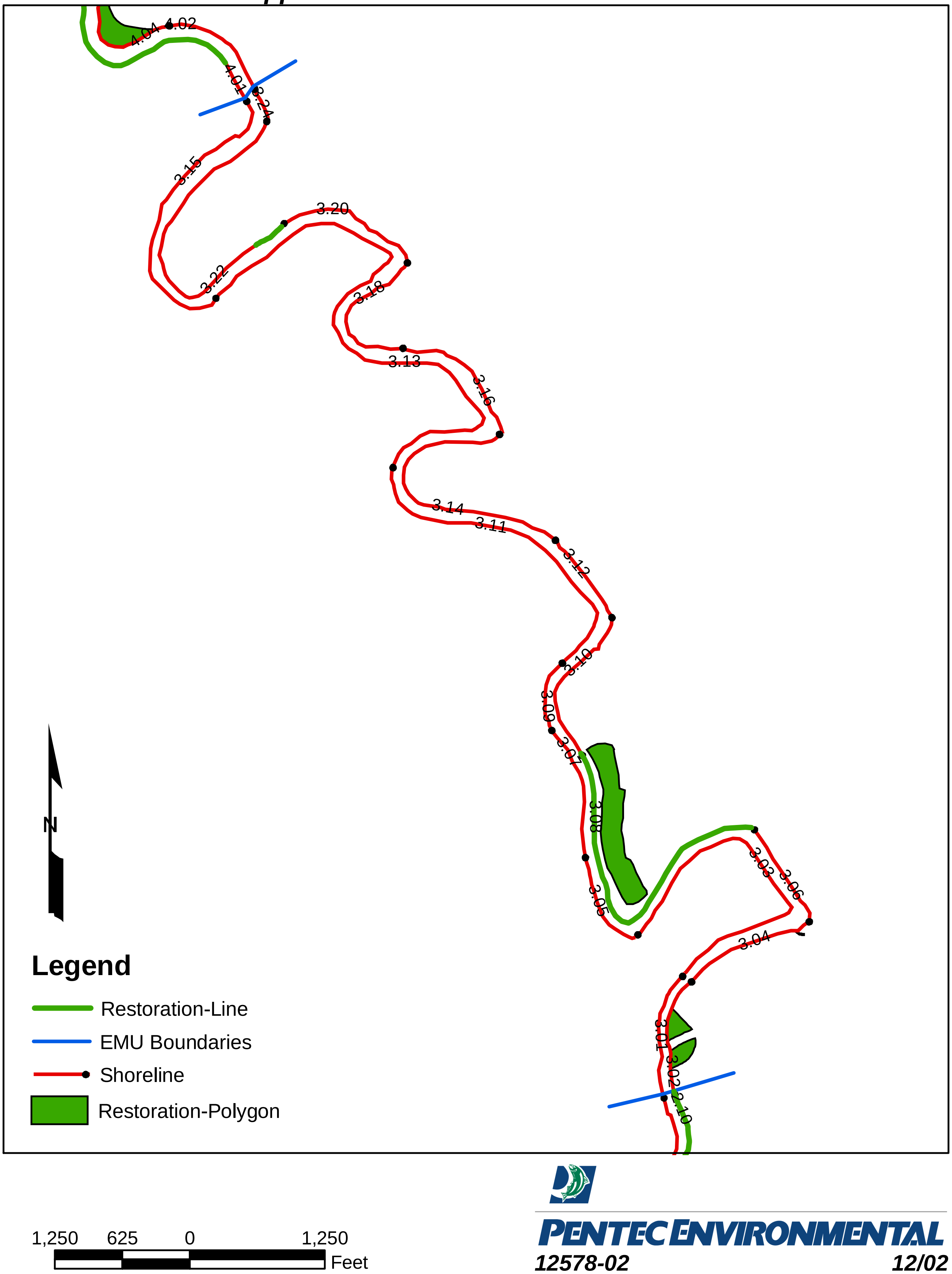
12578-02 ***12/02***

Figure 13

EMU 3 Restoration Opportunites



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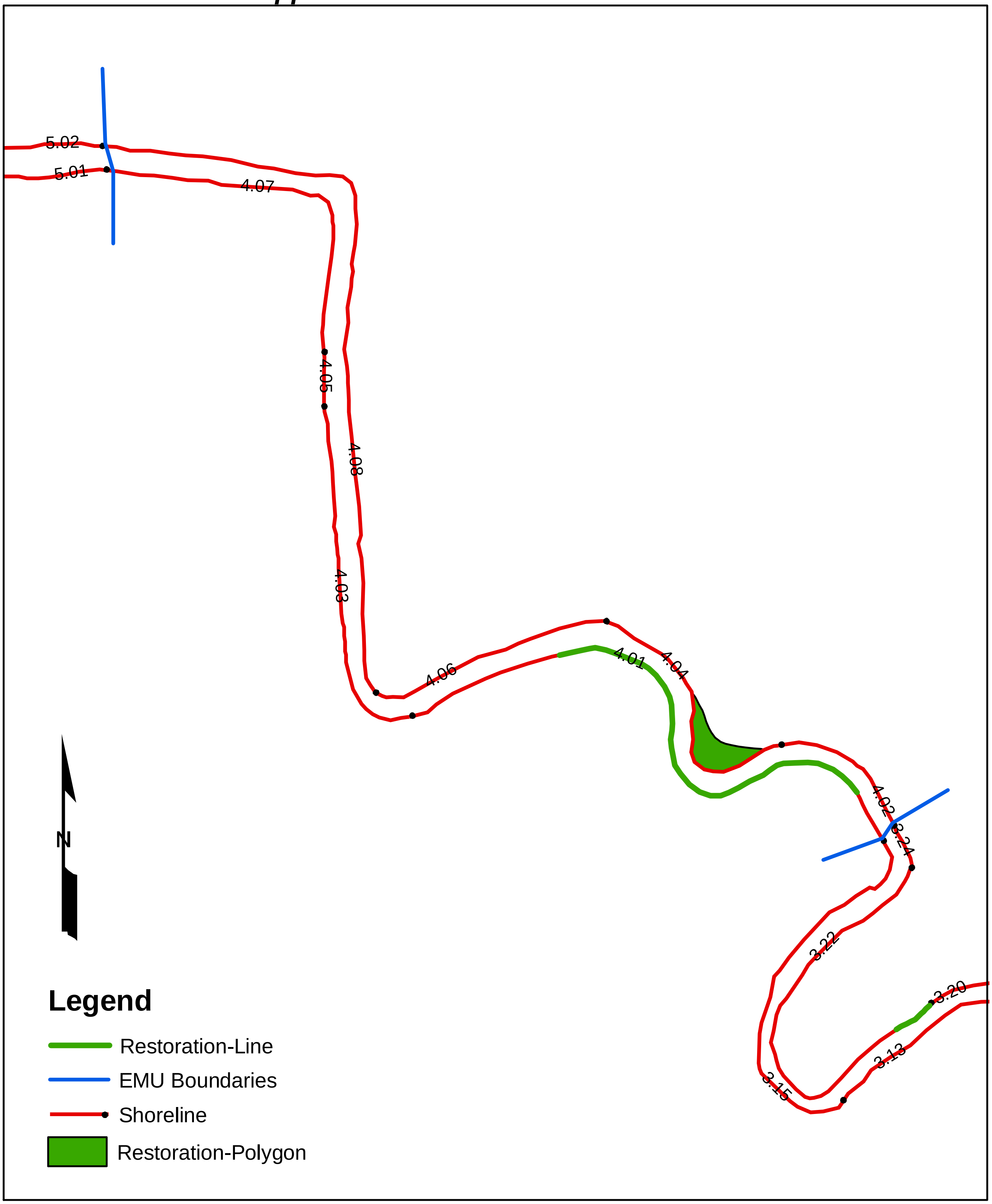
12578-02 ***12/02***

Figure 14

EMU 4 Restoration Opportunities



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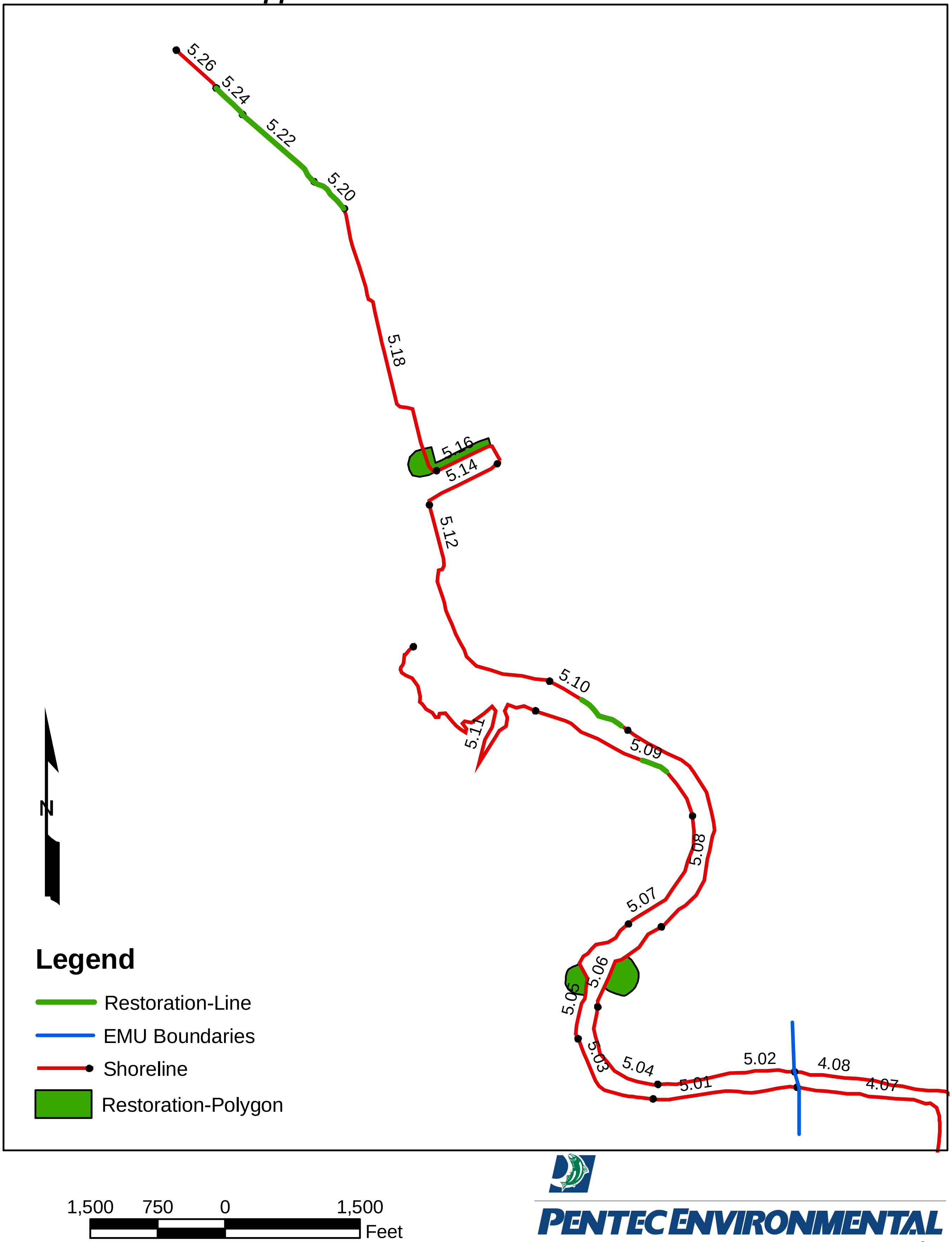
PENTEC ENVIRONMENTAL

12578-02 ***12/02***

Figure 15

EMU 5 Restoration Opportunities



PENTEC ENVIRONMENTAL

12578-02 ***12/02***

Figure 16

PHOTOS

Photograph 1 – EMU 1 (AU 1.05). Blackberry-dominated riparian zone; note large amount of LWD in mid-channel.

Photograph 2 – EMU 1 (AU 1.03). Culverted creek mouth.

Photograph 3 – EMU 2 (AU 2.1 on right). Low quality riparian vegetation; scattered ornamental trees.

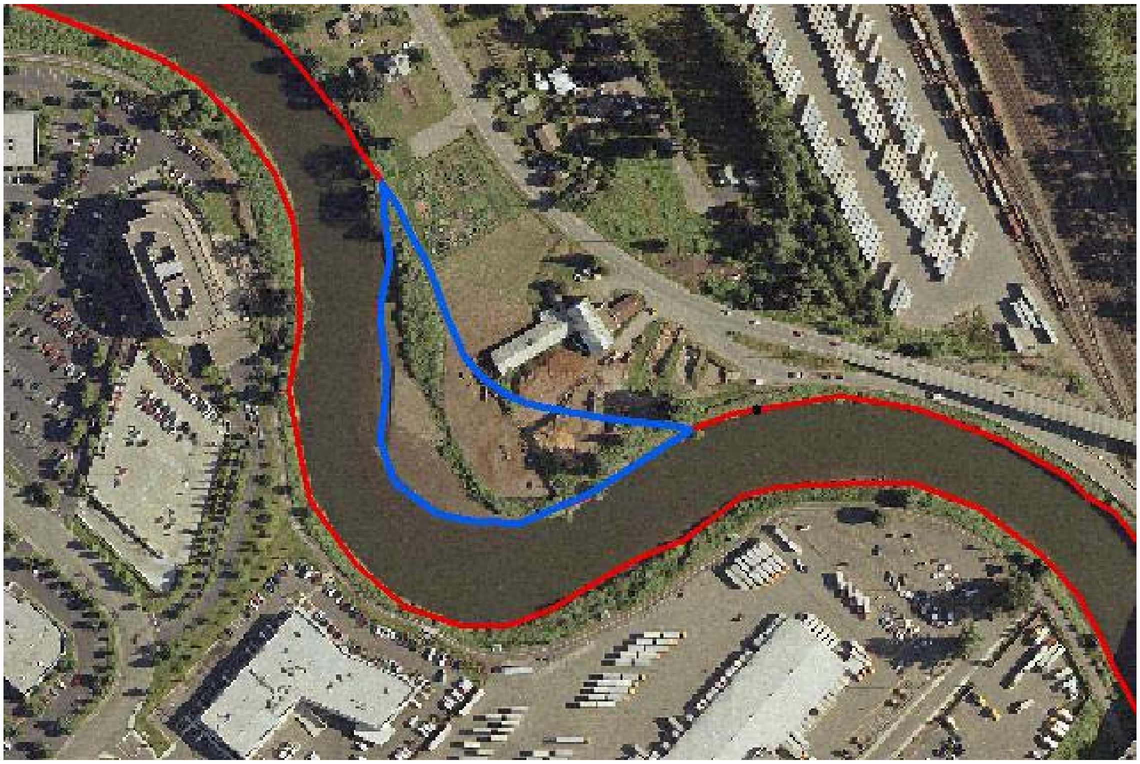
Photograph 4 – EMU 2. AU 2.02B, Desimone levee set back on left; AU 2.01B, Segale bank restoration on right.

Photograph 5 – EMU 3 (AU 3.18). Vegetation overhanging low tide mud bank.

Photograph 6 – EMU 3 (AU 3.8 on left). Good quality riparian habitat with overhanging deciduous trees.

Photograph 7 – EMU 3 (AU 3.15). Steel sheet pile bulkhead.

Photograph 8 – EMU 4 (AU 4.08). LWD and narrow riparian zone.



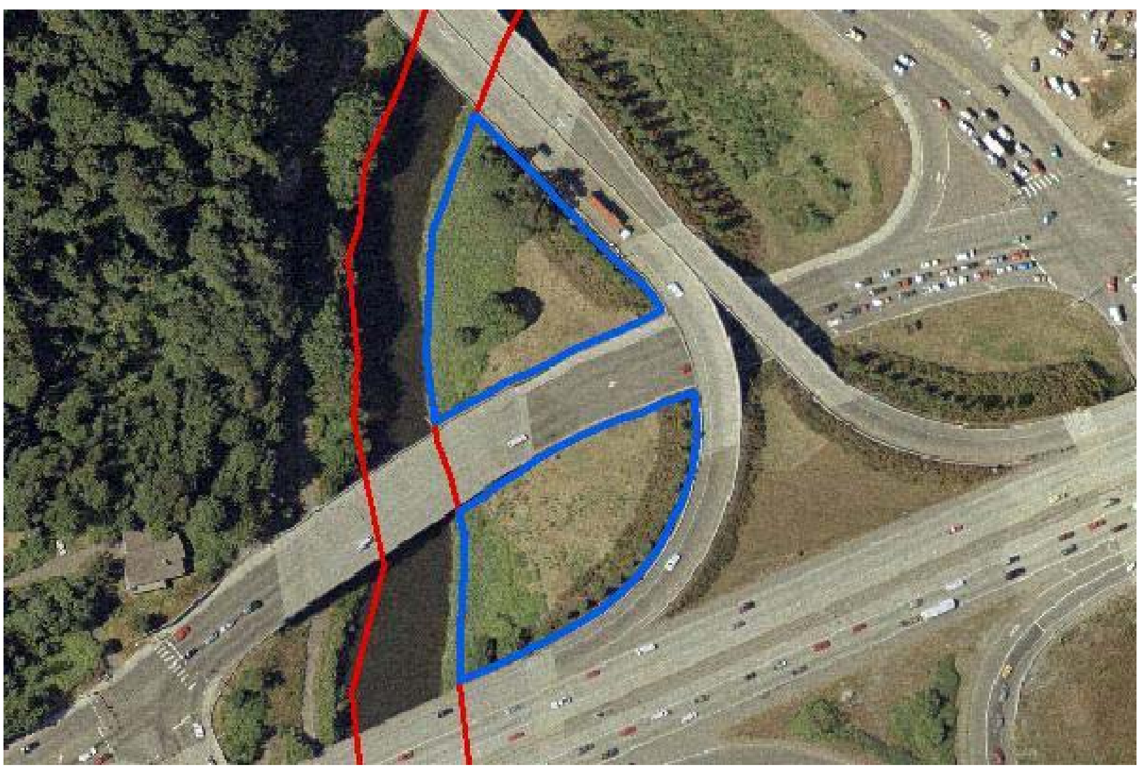
Photograph 9 – EMU 4 (AU 4.4, inside of bend). Codega Farms restoration site.

Photograph 10 – EMU 5 (AU 5.22). Mudflat adjacent to river channel and large overwater structure.

Photograph 11 – EMU 5 (AU 5.07). High quality riparian zonation of mudflat, marsh, shrub, and trees.

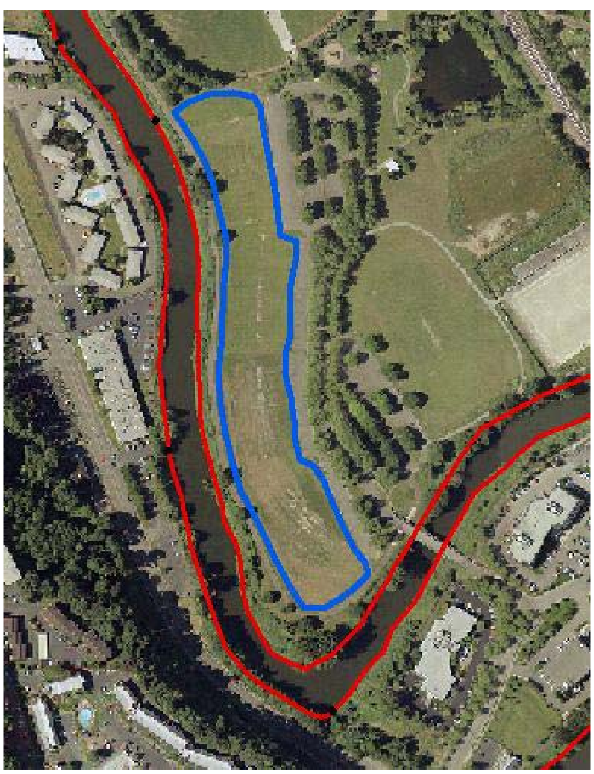
Photograph 12 – EMU 2 (AU 2.02B). Desimone levee setback project; embankment planted with native vegetation spring 2002.

Photograph 13 – EMU 1. Large agricultural field; potential for extensive off-channel and side-channel habitat.

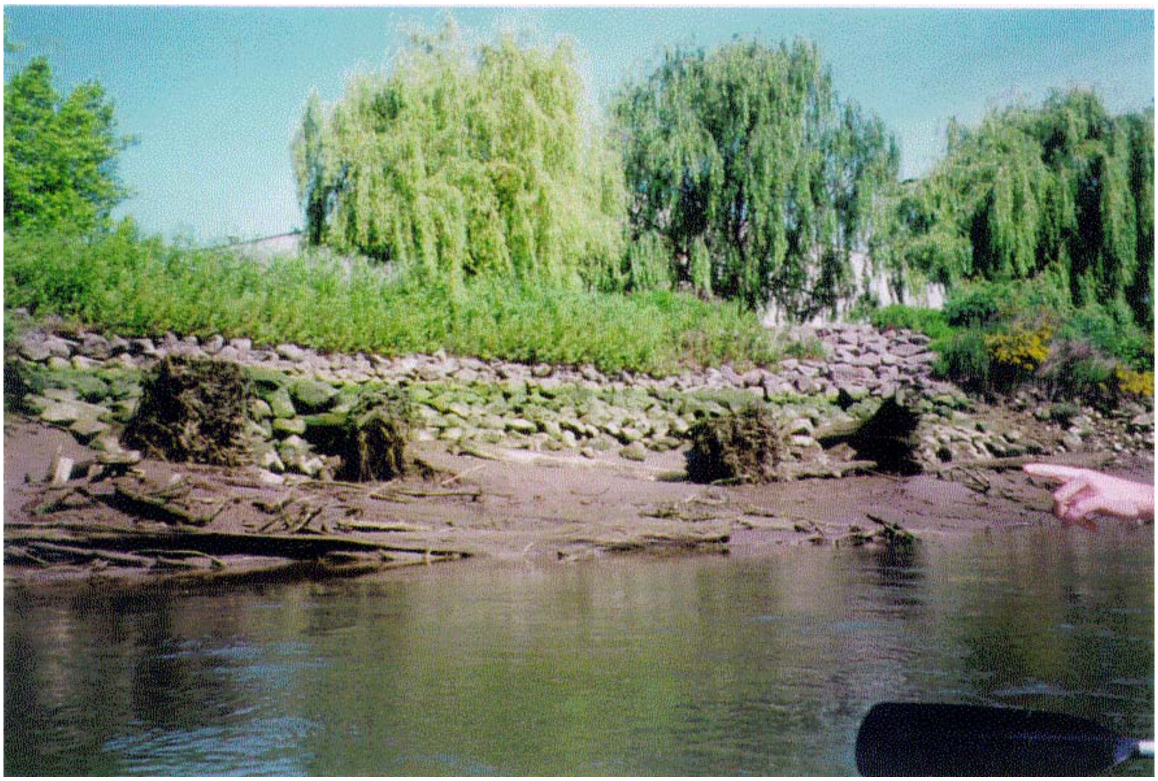


Photograph 14 – EMU 3 at I-405. Potential for off-channel creation between highways.

Photograph 15 – EMU 3 (AU 3.04). Potential to deepen entrance channel to existing off-channel restoration site.



Photograph 16 – EMU 3 (AU 3.08).
Vacant land along river in Fort Dent Park;
possible site for side-channel creation.



Photograph 17 – EMU 5 (AU 5.09). Incorporation of LWD and riparian plantings into bank stabilization.

Photograph 18 – EMU 5 (AU 5.06). High quality mudflat below northwind weir rapids.

APPENDIX A
SELECTED CRITERIA FROM TIDAL HABITAT MODEL DEFINED

APPENDIX A

FIELD MANUAL FOR TUKWILA SHORELINE INVENTORY (BASED ON MODIFIED SEWIP TIDAL HABITAT MODEL QUESTIONNAIRE)

INTRODUCTION

BACKGROUND

The Snohomish Estuary Wetland Integration Program (SEWIP) Tidal Habitat Model (THM) was the result of substantial modifications to the anadromous fish portion of the Mudflat Model developed originally by an interagency technical advisory committee (City of Everett et al. 1997). The technical basis and applicability of the Mudflat Model to anadromous fish was reviewed and modified as a result of the 1999 listing of several Puget Sound anadromous salmonids stocks as threatened with endangerment under the Endangered Species Act. The model modifications were focused on more accurately describing the quality of tidal habitats for salmonids, with emphasis on chinook salmon, coho salmon, and bull trout. Ecological functions provided by habitats in the SEWIP area and along the Green/Duwamish River in Tukwila include feeding, migration, predator avoidance, and saltwater adaptation. As a result, the approach and questionnaire developed for field application of the THM was used as a starting point in the development of the approach and field questionnaire for the Tukwila inventory.

However, because the Tukwila inventory was intended to inform the City's planned update of its Shoreline Master Program (SMP), the questionnaire was modified to expand information requirements for adjacent land uses and riparian vegetation.

MODIFICATIONS TO THE TIDAL HABITAT MODEL

For this project, the THM questions describing inwater and riparian habitat features were retained and questions related to nearshore habitat features not present in a river system were deleted. The resulting questionnaire (Table 1) generally describes the hydrological and physical components of the AU: freshwater source, bulkheading/riprap, levee/dike/revetment with a focus on riparian conditions. Additional data on riparian plants and land uses were recorded.

APPLICABILITY AND GENERAL ASSUMPTIONS

Although developed for use as part of the overall SEWIP, the indicators present in the questionnaire are also considered to be fully applicable to other estuary and nearshore conditions around the greater Puget Sound area. The questionnaire is designed to be relevant to both tidal estuarine habitats and lower river freshwater environments. Some model questions may not be applicable for both estuarine and riverine habitats; if the question is not relevant (or the indicator is not present), the question is simply left blank as a nonaffirmative answer. The questionnaire is focused only on indicators that are of direct or indirect relevance to anadromous salmonids, and focuses on existing or presumed indicator conditions, not on the processes necessary to maintain those conditions. Although the questionnaire is clearly focused on the several important functions provided by estuarine and riverine areas to juvenile salmonids, certain features of the questionnaire also serve to rate quality for adult salmon. Also, habitat conditions favorable to salmon are generally considered favorable for other natural resources expected in the same areas, for example, other fish, shorebirds, and small mammals.

DOCUMENT PURPOSE

This document sets forth the underlying rationale and assumptions for each question and provides the data user with background information and protocols to assist in data applications. The modified questionnaire is composed of 24 questions. To refine the sensitivity to complexities and gradients in the environment, several questions include multiple subquestions, with only one subquestion to be answered under each question. This manual lists and describes the main questions. All questions and subquestions can be found in the field form; see Table 1.

MAPPING METHODOLOGY

The AUs were first delineated on a series of 2000 aerial ortho photographs obtained from the City of Tukwila. Major categories of shoreline modification (dikes, levees, revetments) were used in conjunction with major transitions in adjacent land use, riparian condition, or shoreline morphology in the initial delineation (done in the office) of assessment units (AUs). This photo series was taken to the field and used as the base map and a primary data source for field assessment of each AU using the questionnaire. Some AU boundaries were adjusted on the basis of field observations of transitional conditions that were not evident in the photos alone.

Final AU boundaries were transferred onto a second series of aerial photographs available in the City's Geographic Information System (GIS) system so that the stream length of each AU could be calculated.

In defining the specific AU boundaries in the waterward and landward directions, the following conventions were used:

1. Waterward Boundary

   - In the mainstem Green/Duwamish River, below the turning basin (RM 5.3), waterward boundary was set at the edge of the dredged navigation channel or at the -10 ft mean lower low water (MLLW) contour.

   - Above RM 5.3 a line drawn evenly between both banks signifies this boundary.

2. Landward Boundary

   - In all cases, the landward boundary was set at 200 ft landward from the ordinary high water (OHW) line, to include the riparian zone and land use activities in the shorelines.

Several questions in the questionnaire are scored on the basis of portions of the AU that lie within the littoral zone. The littoral zone is defined as that area between mean higher high water (MHHW) (about +12.0 ft MLLW) to -10 ft MLLW, the area typically considered to be important habitat for juvenile anadromous fish during their early estuarine life history (e.g., McDonald et al. 1987). Above the limits of tidal action and in areas where the upper beach is vegetated with water-dependent vegetation, the OHW line was used to define the upper limit of the littoral zone and the beginning of the 200-ft shoreline zone.

ASSUMPTIONS AND FIELD PROTOCOL

INDICATOR GROUP - HYDROLOGY

Question 1: Does AU have a vernal or perennial freshwater stream or spring?

Assumptions: This indicator addresses the feeding and osmoregulatory (saltwater adaptation) functions. Fresh water entering a tidal littoral habitat is assumed to provide increased ecological function by providing a range of small-scale salinity gradients that allow juvenile salmonids to select a salinity compatible with their stage of osmoregulatory adaptation (Thorpe 1994, Healey 1991, Rich 1920). Contributions of fresh water at the saltwater interface can also add diversity of plant and prey assemblages. For example, saltmarshes with freshwater input are more likely to support sedge assemblages that produce prey used by juvenile chinook (Pomeroy and Wiegert 1981). Freshwater streams and springs are especially useful for ocean-type chinook fry that outmigrate to estuary environments shortly after emergence from the gravel (Healey 1982).

Protocol: Answer "yes" if the AU has a freshwater stream or spring during the spring outmigration period. Spring or stream must be of sufficient flow to either modify the vegetative assemblages present or maintain a channel with sufficient depth to provide juvenile salmonids refuge during low tides. Freshwater inflow should be sufficient that salinity in the stream is lower than the ambient tidal water flowing by the AU. Note that presence of a channel is scored separately in Questions 4 and 5; thus, additional value is assumed if the channel is formed by freshwater rather than tidal flow.

Scoring can be done from maps or aerial photographs but may require field survey to verify that the water flow has significant freshwater inflow and does not consist merely of tidal drainage.

Question 2: Does AU have refuge from high velocities (e.g., during maximum ebb tide)?

Assumptions: This indicator addresses the migration function and is relevant to estuarine and riverine AUs only. Refuge from high velocities during river flooding or during maximum ebb tides allows juvenile salmonids to remain in the estuarine environment longer, potentially increasing the opportunities for feeding and growth before continued migration into the marine environment (Maser and Sedell 1994, Levy and Northcote 1981).

Protocol: Determination that refuge from high velocities is present in an AU may be possible from high-quality aerial photography, but field verification is usually necessary. Features providing this refuge include, but may not be limited to, large woody debris (LWD), large boulders or bedrock features, blind sloughs, and off-channel mudflat/marsh complexes with low tide refuge. In some cases, artificially constructed features such as wing walls, bridge piers, or riprap may also provide refuge from high velocities (e.g., Maser and Sedell 1994, CDFG 1995).

Question 3: Does AU contain a tidal channel?

Assumptions: This indicator addresses the predation/protection and feeding functions. Shallow tidal channels in marsh/mudflats provide low-tide refuge and feeding opportunities for juvenile salmonids (e.g., Levy and Northcote 1982, Levings 1982, Ryall and Levings 1987, Healey 1991). These functions are especially important for chinook fry (Congleton et al. 1981, Levy and Northcote 1982), as movement by this species into deeper water appears to be controlled by size (Thorpe 1994), probably as a manifestation of predator avoidance. Presence of a channel within an AU allows fish to remain within the AU during low-tide periods (Healey 1982) and prolongs the opportunities for fish to exploit food resources within the AU. Deeper channels and those that remain flooded at tides equal to or lower than MLLW provide additional benefits as deepwater refuge from certain types of predators (e.g., Levy and Northcote 1982). Shallower drainages (i.e., those that do not retain sufficient water for juvenile salmonid residence when the tide falls below mean sea level [MSL]) are still valuable but provide those values for only a portion of the tidal cycle.

Protocol: Unless photos taken at different tide stages are available, scoring this indicator requires a site survey. "Yes" is the appropriate answer to Question 3a, if the channel is either deep enough (e.g., deeper than 0 ft MLLW) or contains enough runoff flow to provide habitat for juvenile salmonids during low tides. If a natural channel is present but it does not provide habitat below mean tide level, answer "yes" to Question 3b.

Question 4: Is tidal channel dendritic or highly sinuous?

Assumptions: This indicator addresses the predation-protection and feeding functions. Most natural unconfined stream channels are sinuous, and channels through broad natural mudflats are often also dendritic, with first-, second-, and third-order channels (Congleton et al. 1981). Increased length provided by channels that are either dendritic or highly sinuous provides increased low-tide refuge area and increased access to more of the AU at more tidal elevations. Healey (1982) also notes that sinuous channels increase trapping of detritus, increasing prey productivity.

Protocol: Channel morphology can be determined using aerial photographs or by site survey. A highly sinuous channel is defined as one that has sinuosity of greater than 1.5; i.e., where the channel length between two points is 1.5 times the straight line distance between the two points. A dendritic channel system within an AU must have multiple secondary channels; the secondary channels can be shallower than the main channel.

INDICATOR GROUP – WATER QUALITY

Question 5: What range of salinity is present in AU?

Assumptions: This indicator addresses the feeding and osmoregulatory (saltwater adaptation) functions. Presence of a range of salinities within the estuarine environment provides staging opportunities for outmigrant and returning salmonids to adjust physiologically between fresh and salt water. The range of salinities available within the estuary transition zone also affects the juvenile salmonid forage base by providing niches unavailable in fresh water only, and thereby a more diverse assemblage of food organisms (e.g., insects and crustaceans) (Pentec 1992). For the function of physiological transition (i.e., up- or down-regulation of gill ATPase activation for adjustment to changing NaCl concentrations), AUs with polyhaline salinities (marine conditions with > 18 parts per thousand [ppt] salinity) are considered less important to salmonids than AUs with typically oligohaline or mesohaline salinities (variable salinity often ranging between 0.5 and 5 ppt but occasionally ranging as high as 18 ppt). This difference in importance is a result of the fact that most physiological changes that occur during smoltification occur at the lower salinities (Healey 1982). However, species that spend a greater portion of their early life history rearing in fresh water (e.g., coho, bull trout) may engage in extended rearing in an AU that has predominantly fresh water (almost always < 0.5 ppt).

Protocol: The range of salinities within an AU may be based on location within the planning area, ascertained from previous monitoring efforts, or can be evaluated during field survey using either a hydrometer or refractometer. For example, areas in EMU 1 and 2 are by definition fresh water (answer "yes" to Question 5a). AUs in EMUs 3 through 5 are polyhaline (answer "yes" to Question 5b).

INDICATOR GROUP – VEGETATED EDGE

Two aspects of the nature of the riparian zone bordering estuarine and nearshore AUs are considered in the questionnaire: the extent of tidal or freshwater marshes below OHW and the extent of riparian scrub-shrub and forest above OHW. It is recognized that the several functions of riparian buffers typically identified as applicable along streams higher in the watershed (e.g., Spence et al. 1996, Brosofske et al. 1997, Hetrick et al. 1998a,b) are not fully applicable in providing similar functions in the estuary and lower riverine areas. Nonetheless, these riparian zones do affect the quality of these habitats for salmonids. Questions 6 through 14 address the feeding and refuge (predation/protection) functions.

Question 6: What is the vegetated edge below OHW?

Assumptions: Many tidal areas are bordered by intertidal marshes that serve several of the buffer functions typical in more fluvial systems. For example, the marsh may provide refuge (for juvenile salmonids that can swim in among the vegetation to avoid predators), food (e.g., insect production [Cordell et al. 1998], amphipods [Levings 1990]), and a source of detrital energy to important food webs. Marshes are a principal foraging area for ocean-type chinook fry (Levings 1990, Thorpe 1994) and are extensively used by salmonids at night (CDFG 1995). The THM assumes that juvenile salmonids utilize primarily the waterward edge of tidal marshes and do not penetrate more than a few feet into densely vegetated areas; thus, full functional value is given for an AU with saltmarsh around 50 percent of its shoreline that is greater than 10 ft in width. The additional indirect functions provided by AUs with a tidal marsh of native vegetation covering more than 25 percent of their area are recognized in Question 6d.

Protocol: In most cases, width of the vegetated edge must be assessed from site survey of the AU, as aerial photography will not provide the accuracy to delineate the vegetated edge at the widths defined by the questionnaire. Also, assessment of species composition (i.e., non-native vs. native) is required to address the multiplier defined in 6d. Answer "yes" to Question 6d if native species occupy the vegetated edge over greater than 25 percent of the AU surface area below OHW.

Question 7: List type/species for grasses and sedges below OHW.

Protocol: List the species of grasses and sedges observed along the shoreline, for example, *Carex, Scirpus, Juncus, Deschampsia, Agrostis, Plantago, Triglochin, Phalaris.*

Question 8: List type/species for shrubs below OHW.

Protocol: List the species of shrubs observed along the shoreline, for example; *Salix, Rubus, Polygonum*.

Question 9: What is the vegetated edge above OHW?

Assumptions: If the marsh fringe is of sufficient width, the contribution of riparian forests at higher elevations (> OHW) is reduced, or, at the very least, effective only during the highest tides. For example, trees may provide shade along the edge of the high marsh that is seldom underwater; hence, shading will have little effect on water temperature. However, if the saltmarsh fringe is relatively narrow, riparian forests along the edge of the saltmarsh may provide highly effective shading over the water, and relatively increased contributions of organic components to support the detrital food web over that contributed by saltmarsh vegetation alone. Such conditions could be found particularly within the upper estuary. Riparian scrub-shrub and forests are assumed to begin providing significant functions in estuarine and nearshore areas at widths exceeding 25 ft or covering the waterward sides and tops of dikes. Credit is given even where the riparian vegetation is dominated by non-native species such as blackberry, on the assumption that this vegetation will still provide shading, insect fall, and litter fall to the aquatic environment. Additional credit is given under Question 10 if the vegetation is predominantly native species.

Protocol: Width and composition of the riparian vegetation is usually assessed from a site survey of the AU, as aerial photography may not provide the accuracy to delineate the riparian composition at the widths defined by the questionnaire. Answer "yes," as appropriate, among the three qualifiers (i.e., 9a,b,c) based upon field measurements or estimates of the width of the riparian zone above OHW and the extent of the AU high-water margin that has riparian scrub-shrub or forests greater than 25 ft in width. Credit can be given for vegetated widths less than 25 ft where the shoreline *configuration* supports riparian vegetation for the full width that may interact with the aquatic environment (e.g., the waterward slope and top of a dike).

Question 10: Is the riparian zone vegetation dominated by native species?

Assumptions: It is assumed that riparian vegetation that includes a mix of native species will provide a greater food resource to juvenile salmonids than will a riparian border of non-native species.

Protocol: If the riparian scrub-shrub or forest vegetation is dominated (>50 percent of the total cover) by native species, answer yes to Question 10.

Question 11: Does the riparian zone of the AU provide a significant source of LWD?

Assumptions: This indicator addresses the feeding and predator/protection functions. In general, the role of LWD in providing fish habitat within the estuary is assumed to be of lesser importance than its role in freshwater fluvial conditions upstream. This is because of tidal water-level changes, which leave anchored wood submerged, or out of the water, a portion of the time, and because of the reduced importance of the pool-forming function of wood in estuaries where juvenile salmonid use may be less than year-round. Late seral stands of riparian forest are necessary to recruit LWD into the active stream channel or marshes accessible to anadromous fish. Immature riparian forests do not provide LWD that will be retained for a long enough period of time in the channel to be considered important fish habitat elements. To be of direct habitat value to salmonids, LWD must be large enough to be retained in the channel and thereby provide hydraulic control, cover, and velocity refuge. Large wood also provides for organic contributions to the estuary and thereby supplements the detrital base (Maser and Sedell 1994).

Relatively smaller sizes of LWD can be retained in lower-energy, lower river or off-channel estuarine habitats and thus provide the same functions as larger LWD in more active channels. Mature trees considered for this purpose are those with diameter at breast height (dbh) of more than 0.3 m. Trees that recruit to the river or estuary from the adjacent riparian zone are assumed to have limbs and rootwads attached; thus, the criterion for recruitment is similar to that for inwater LWD with limbs or rootwads (Question 16).

Protocol: The state of maturity of a riparian stand can be evaluated from recent, high-quality, aerial photographs, or from field surveys. Answer "yes" to Question 11 if at least 50 percent of the riparian zone of the AU contains mature trees that meet the 0.3-m dbh size criterion, and if those trees have the potential to fall into areas accessible to juvenile salmonids, generally considered to be below MHHW. If the area between MHHW and OHW consists of a broad, vegetated marsh, trees that fall from the riparian forest will land in these vegetated areas and have little potential to provide the full function of LWD in stream or shoreline areas. Although such trees may still provide limited function, they would not be considered to be a significant source of LWD in the context of the questionnaire. Diameter at breast height should be considered from field measurements of at least six trees within the AU.

Question 12: List type/species for grasses and sedges above OHW.

Protocol: List the species of grasses and sedges observed along the shoreline above OHW.

Question 13: List type/species for shrubs above OHW.

Protocol: List the species of shrubs observed along the shoreline, for example, *Salix, Rubus, Polygonum*.

Question 14: List type/species for trees above OHW.

Protocol: List the species of trees observed along the shoreline above OHW, for example, *Populus balsamifera, Acer macrophyllum, Fraxinus oregana, Pseudotsuga menziesii, Pinus* spp.

INDICATOR GROUP – LAND USE

Question 15: List adjacent land uses.

Protocol: List the adjacent land uses within the 200-ft shoreline zone, in order of distance, for example, riparian shrub, recreational (path), commercial/industrial, infrastructure (roads, railroad), or residential.

INDICATOR GROUP – SPECIAL HABITAT FEATURES

Question 16: Does the AU contain significant densities of LWD?

Assumptions: This indicator addresses the feeding and predation/protection functions. The relative importance of LWD in providing physical habitat and hydraulic control in the estuary and marine nearshore areas is believed to be lower than in upstream reaches, but it is still important (e.g., Maser and Sedell 1994). Suitable criteria for wood-loading in estuaries and marine areas have not been established by quantitative research and likely would vary substantially over the gradient of conditions present.

The retention of wood in the channel is a function of channel width, wood size, and wood type, whereby wide channels retain proportionately less wood per unit channel length than narrower channels. Most of the wood recruited into estuaries and nearshore areas is derived from upstream sources, not from riparian stands immediately adjacent to AUs within the estuary. For purposes of this questionnaire, LWD is defined to include the following:

- logs with length > 10 m and diameter > 0.6 m
- logs/trees with rootwad and/or branches, length > 10 m, and diameter > 0.3 m
- stumps with diameter > 1 m

Wood-loading densities proposed for the estuary reflect a reduced ecological function of LWD in estuary and nearshore areas compared with densities suggested by the Washington State Department of Natural Resources (WDNR) as needed to rank as "good" loading levels in streams. The highest densities range in the questionnaire would rate as "fair" under the WDNR (1994) watershed analysis protocols for channel widths less than 20 m in streams. This rating is justified on the basis of the reduced functionality of LWD in the lower river and estuarine environment (for salmonid habitat), and the "channel widths" found in the estuary that often exceed 20 m. The maximum range LWD assessment values would be within the range considered "good" by Ralph et al. (1991) for Washington streams with channel widths less than 20 m in unmanaged forests (range reported: 0.46 to 3.95 pieces per channel width). LWD criteria have typically been based on number of pieces per linear distance of stream channel, reflecting the derivation of those values.

Protocol: Wood loadings within a channel edge must be assessed by field survey of the AU. Number of pieces by size class along the edge of the MHHW line should be counted along with those visible at lower water levels.

INDICATOR GROUP – STRESSORS

Question 17: Is access to the AU by anadromous fish limited?

Assumptions: Artificial (manmade) barriers to immigration and emigration limit habitat use by salmonids for rearing, and thereby may reduce the overall carrying capacity of the estuarine environment for salmonid production. Any AU with access restricted by an artificial barrier over 90 percent of the time is considered to provide no function for salmonids, and the questionnaire would not be used for such an area. Many portions of estuarine habitats will be naturally restrictive at certain times of the year because of high water temperatures or tidal conditions; such natural restrictions to habitat use are not penalized under this protocol.

Freshwater and estuarine habitat restrictions may represent the single most important element to reducing the ability of a system to support salmonids. Artificial barriers restricting estuarine use such as diking, ditching, dredging, and impassable or restrictive tide-gated culverts (Beechie et al. 1994) are generally not present in the study area.

Question 18: Does AU shoreline include riprap or vertical bulkheads extending below MHHW?

Assumptions: This question addresses the feeding, migration, and predator-avoidance functions, as well as shoreline sediment source and transport processes, and reflects the horizontal extent of shoreline hardening. Although quantitative data are lacking, it is widely assumed that juvenile salmonids encountering vertical bulkheads or steep riprap as they migrate along estuarine or riverine shorelines are more vulnerable to predation than they are as they migrate along gradually sloping beaches (e.g., Heiser and Finn 1970, Thom et al. 1994). Smaller fish (e.g., pinks, chums, and ocean-type chinook) are considered to be more vulnerable to predation along a vertical bulkhead than larger fish such as stream-type chinook, coho, and bull trout. Limited observations of predation along bulkheads and riprap in the Everett Harbor area (Pentec 1997) found that larger salmonids (possibly bull or cutthroat trout) were the primary predators on smaller salmonids. Thus, vertical bulkheads result in a lesser reduction of habitat function for bull trout and coho than for chinook. Vertical bulkheads also provide less shallow-water surface area for generation of epibenthic prey favored by smaller juvenile salmonids and may force fish to switch to pelagic prey.

Riprapping or bulkheading of shorelines also interferes with normal shoreline sediment erosion and deposition processes (e.g., Canning and Shipman 1995). Thus, bulkheads or riprap at any slope that limits natural shoreline processes is scored under this question.

Protocol: This question can be answered either through site photographs of sufficient detail or through a site visit. Answer "yes" to Question 18a if the AU high-water shoreline has 10 to 50 percent riprap or vertical bulkheads, or "yes" to Question 18b if more than 50 percent of the shoreline is hardened.

Question 19: Do riprap or bulkheads extend below mean sea level over the majority of the hardened AU shoreline?

Assumptions: This question addresses the feeding, migration, and predator-avoidance functions and reflects the vertical extent of shoreline hardening. The tidal nature of littoral habitat is recognized along with the fact that riprap or bulkheading can eliminate a large proportion of the intertidal habitat that would normally be available to juvenile salmonids. AUs in which the majority of the shoreline hardening extends below MSL (about +6 ft MLLW) will lack essential natural features of upper intertidal habitat and will be reduced in overall area. Migrating fish will encounter the hardened shoreline over 50 percent of the time. Therefore, this condition is noted with a distinct question beyond Question 18.

Protocol: This question can be answered either through site photographs of sufficient detail or through a site visit. Answer "yes" to Question 19 if shoreline hardening extends below MSL over a major portion (e.g., more than 25 percent) of AU shoreline noted as hardened in Question 18.

Question 20: List armoring/substrate below OHW.

Protocol: List nature of shoreline armoring or substrate below OHW, for example, riprap, wooden bulkhead, steel bulkhead.

Question 21: List armoring/substrate above OHW.

Protocol: List armoring/substrate above OHW, for example, riprap, wooden bulkhead, steel bulkhead.

Question 22: Does the AU have one or more finger piers or marginal wharfs?

Assumptions: This question addresses the predator-avoidance function. Limited studies and observations have shown that a portion of shoreline-migrating juvenile salmonids, upon encountering a large overwater structure in marine areas, may either delay further shoreline movement for a time or move waterward along the margin of the wharf (e.g., Pentec 1997, Heiser and Finn 1970). It is presumed that those fish that move into deeper water or farther from shore may become more vulnerable to certain types of predation than they would be had they not encountered the wharf, although there is little information in the literature to document this predation (Pentec 1997, Nightengale and Simenstad 2001). The degree of light penetration under the structure is considered to be important in determining the degree of interruption of migration induced by a wharf, but Ratte and Salo (1985) found no significant difference in the numbers of juvenile salmonids captured under a wharf in Tacoma between periods when the under-wharf area was artificially lighted and when it was unlit.

Protocol: This question can be answered either through site photographs or through a site visit. Answer "yes" to Question 22a if the AU has one finger pier, dock, or wharf greater than 8 ft wide, or "yes" to Question 22b if the AU has either two or more docks that are 8 to 25 ft wide or a single structure that is more than 25 ft wide.

Question 23: Is more than 10 percent of the AU littoral area covered with overwater structures that are more than 8 ft wide?

Assumptions: This question addresses the feeding, migration, and predator-avoidance functions. Shading of littoral area bottoms can reduce or eliminate benthic primary productivity. The effect is seen between elevations of about +8 ft MLLW (on most substrates; OHW in a marsh area) and -10 to -25 ft MLLW (depending on water clarity). Above +8 ft MLLW, there is little primary production on most substrates and rates of production are more limited by high light and desiccation; reduced light levels (e.g., partial shading by a narrow dock) can actually increase primary productivity at higher elevations. Overwater structures such as marina floats, while they may produce substantial epibenthic prey (e.g., Kozloff 1987), can create a maze that surface-oriented juvenile salmonids can follow in random directions, potentially delaying their progress along a given reach of shoreline. Overwater structures, like finger piers, can also lead fish into deeper water where they may be more vulnerable to certain types of predation than they would be in shallower waters. However, Cardwell et al. (1980) found that abundance of chinook and coho salmon, as well as herring, was higher inside the Skyline Marina than outside, and they noted a scarcity of fish and avian predators on juvenile salmonids within the marina. They also reported that prey favored by chinook and coho juveniles were more abundant in the marina than in nearby Burrows Bay.

Protocol: This question can be answered by scale drawings, aerial photographs, or by on-site measurements. Areas with light-transmissive grating or other material should be subtracted from the area of coverage before scoring this question. Answer "yes" to Question 23a if the AU has a total overwater coverage of 10 to 30 percent of its total littoral area; "yes" to Question 23b if overwater coverage is between 30 and 50 percent; "yes" to Question 23c if overwater coverage is between 50 and 75 percent; and "yes" to Question 23d if overwater coverage is greater than 75 percent.

Question 24: Is littoral area in the AU routinely disturbed by propeller scour, oil spills, or dredging?

Assumptions: This question addresses the feeding and salmonid health functions. Routine or recurring disturbances of the benthic environment that reduce the productivity or health of epibenthic prey of salmonids degrade the quality of the habitat. Propeller scour can resuspend finer and more richly organic surficial sediments that provide habitat for epibenthic zooplankters. Chronic oil releases can leave the epibenthos in a constant state of early recovery from an oiling event and could result in increased bioaccumulation of PAHs in salmon via a sediment-to-epibenthos pathway (e.g., Arkoosh et al. 1998). Dredging will eliminate less mobile existing benthos from an area and may result in a postdredging bottom that is less rich in organic matter, and which serves as a basis for epibenthic food webs upon which juvenile salmonids are dependent (e.g., Healey 1982). However, recovery of benthos, and especially of epibenthos, is expected to be rapid (e.g., McCauley et al. 1977, Richardson et al. 1977, Romberg et al. 1995.)

Protocol: Answer "yes" to Question 24 if any one of the following is applicable:

1. AU is sufficiently shallow to be scoured by vessel propeller wash over 25 percent of the littoral portion of the AU on a recurring basis.

2. The nature of use of the AU or adjacent areas is such that oil sheens are frequently visible on the water surface along the shoreline and can be assumed to affect at least 25 percent of the AU on a recurring basis.

3. The AU contains areas that are dredged for maintenance of navigation depths on a recurring basis; e.g., more than once every 6 years.

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APPENDIX B
FIELD DATA

Appendix B - Field Data

													Below OHW		Above OHW							Vegetation above OHW				
AU	Survey Date	Bank	Bank Type	Restoration Type	LandUse_1	LandUse_2	LandUse_3	LandUse_4	Marsh	Riparian	Source of LWD Recruitment	LWD Density	Armoring Type	Substrate	Armoring Type	Substrate	Bulkheads	Piers/Docks	Overwater Structure	Routine Disturbance (Spills/ Dredging)	Grasses/ Sedges below OHW*	Grasses/ Sedges*	Shrubs*	Trees*	Vegetation Quality	Notes
1.01	10/24/02	L	levee/dike	side-channel	agricultural	road	#N/A	#N/A	none	51-100% of shoreline	n	0.5 piece/30m of shoreline	none	none	none	none	none	none	none	n		R-cng	Will, Dog, Bber	Ash	low	
1.02	10/24/02	R	levee/dike	none	riparian vegetation	path	industrial/ commercial	#N/A	none	none	n	0.5 piece/30m of shoreline	none	none	none	none	none	none	none	n		R-cng, Tnze	Bber	Cottn, Dfir, WWill, Bmap	low	
1.03	10/24/02	L	levee/dike	bench	riparian vegetation	road	agricultural	industrial/ commercial	none	51-100% of shoreline	n	none	riprap	none	none	none	none	none	none	n		R-cng	Dog, Bber	Ash	low	
1.04	10/24/02	R	levee/dike	bench	riparian vegetation	path	vacant	#N/A	none	51-100% of shoreline	n	none	none	none	none	none	none	none	none	n			Bber	Cottn, Dfir, Ash, Egrn	low	
1.05	10/24/02	L	levee/dike	side-channel	riparian vegetation	agricultural	#N/A	#N/A	none	51-100% of shoreline	n	1.0 piece/30m of shoreline	riprap	none	none	none	none	none	none	n		R-cng, Mxgrs	Dog, Bber, Knot	Ash	low	
1.06	10/24/02	R	levee/dike	none	riparian vegetation	path	industrial/ commercial	#N/A	none	51-100% of shoreline	n	0.2 piece/30m of shoreline	riprap	none	none	none	51-100% of shoreline below MHHW	none	none	n			Dog, Will, Bber	Cottn, Ash, Brch, Cher, Dfir, Lcst, Lpop	moderate	
1.08	10/24/02	R	natural	side-channel	riparian vegetation	path	recreational	#N/A	none	51-100% of shoreline	n	none	none	none	none	none	none	none	none	n					low	
2.01a	10/24/02	L	levee/dike	none	riparian vegetation	industrial/ commercial	#N/A	#N/A	none	51-100% of shoreline	n	0.2 piece/30m of shoreline	none	none	none	none	none	none	none	n			Will, Knot, Bber	Cottn, Ofir, Bmap	low	
2.01b	10/24/02	L	levee/dike	none	riparian vegetation	path	industrial/ commercial	#N/A	none	51-100% of shoreline	n	1.0 piece/30m of shoreline	riprap	none	none	none	51-100% of shoreline below MHHW	none	none	n			Will		moderate	
2.01c	10/24/02	L	levee/dike	levee set-back	riparian vegetation	path	industrial/ commercial	#N/A	none	51-100% of shoreline	n	0.2 piece/30m of shoreline	riprap	none	none	none	none	2 or more piers or docks >8 feet wide, OR 1 pier or dock >25 feet wide	none	n			Will, Bber, Knot	Cottn, Ash, Brch, Cher, Bmap, Lplain, Ocdr, R-Smap, Oak, Bsprce, Sumac	low	
2.02a	10/24/02	R	levee/dike	none	riparian vegetation	path	industrial/ commercial	#N/A	none	51-100% of shoreline	n	none	riprap	none	none	none	none	none	none	n			Will, Bber	Ash, Cottn, Lpop	low	
2.02b	10/24/02	R	levee/dike	none	riparian vegetation	path	industrial/ commercial	#N/A	none	51-100% of shoreline	n	1.0 piece/30m of shoreline	other	none	none	none	51-100% of shoreline below MHHW	none	none	n		Mxgrs	Will		moderate	expected to increase due to restoration
2.03	10/24/02	L	levee/dike	side-channel	riparian vegetation	road	wetland	#N/A	none	51-100% of shoreline	n	none	riprap	none	none	none	none	none	none	n			Dog, Will, Knot, Bber	Cottn, Mash, Bmap, Cher, Lcst, Egrn	moderate	
2.04	10/24/02	R	levee/dike	bench/sand bar	riparian vegetation	path	industrial/ commercial	railroad	none	51-100% of shoreline	n	0.2 piece/30m of shoreline	riprap	none	none	none	51-100% of shoreline below MHHW	none	none	n		Mxgrs, R-cng	Will, Bber, Knot	Ash, Blmap, Dfir, Cottn, Lpop, Lplain, Map	low	
2.05	10/24/02	L	revetment	riparian enhancement	riparian vegetation	path	road	industrial/ commercial	none	51-100% of shoreline	n	none	riprap	none	none	none	10-50% of shoreline below MHHW	2 or more piers or docks >8 feet wide, OR 1 pier or dock >25 feet wide	none	n		R-cng	Dog, Spir, BB, Bber	Bmap, Ash, Dog, Cottn, Oak, Nut, Lcst	low	
2.06	10/24/02	R	revetment	riparian enhancement	riparian vegetation	road	industrial/ commercial	#N/A	none	51-100% of shoreline	n	none	riprap	none	none	none	51-100% of shoreline below MHHW	none	none	n		R-cng, Tnze	ScotB, Bber	Cottn, Ash	low	
2.07	10/24/02	L	revetment	none	riparian vegetation	path	industrial/ commercial	#N/A	none	51-100% of shoreline	n	none	none	none	none	none	none	none	none	n			BB, Bber	Will, Cottn, Blmap, Ald, R-Smap	moderate	
2.08	10/24/02	R	revetment	bench	riparian vegetation	road	industrial/ commercial	railroad	none	51-100% of shoreline	n	none	riprap	none	none	none	10-50% of shoreline below MHHW	2 or more piers or docks >8 feet wide, OR 1 pier or dock >25 feet wide	none	n		R-cng	Dog, Knot, Bboo, Bber	Blmap, Cottn, Ash, Will, Filb, Lpop	moderate	
2.09	10/24/02	L	revetment	side-channel	riparian vegetation	path	road	industrial/ commercial	none	none	n	none	none	none	none	none	none	2 or more piers or docks >8 feet wide, OR 1 pier or dock >25 feet wide	none	n			Will, Dog, Bber	Ash, Cottn, Will, R-Smap	moderate	
2.10	10/24/02	R	revetment	levee set-back/ riparian enhancement	riparian vegetation	road	industrial/ commercial	vacant	none	51-100% of shoreline	n	0.2 piece/30m of shoreline	riprap	sand	none	none	10-50% of shoreline below MHHW	2 or more piers or docks >8 feet wide, OR 1 pier or dock >25 feet wide	none	n	R-cng	R-cng	Will, SnoB, Dog, Bber, Knot	Cottn, Ash, Blmap, Dfir, Cher, Hthne	moderate	
3.01	10/24/02	L	revetment	side-channel	riparian vegetation	path	road	industrial/ commercial	none	51-100% of shoreline	n	none	riprap	none	riprap	none	none	none	10-30% of littoral area of AU	n			Will, BB, Bber, ScotB	Dfir, Blmap, Ald	moderate	

Appendix B - Field Data

													Below OHW		Above OHW								Vegetation above OHW				
AU	Survey Date	Bank	Bank Type	Restoration Type	LandUse_1	LandUse_2	LandUse_3	LandUse_4	Marsh	Riparian	Source of LWD Recruitment	LWD Density	Armoring Type	Substrate	Armoring Type	Substrate	Bulkheads	Piers/Docks	Overwater Structure	Routine Disturbance (Spills/ Dredging)	Grasses/ Sedges below OHW*	Grasses/ Sedges*	Shrubs*	Trees*	Vegetation Quality	Notes
3.02	10/24/02	R	revetment	off-channel	riparian vegetation	road	vacant	#N/A	none	51-100% of shoreline	n	none	riprap	none	riprap	none	51-100% of shoreline below MHHW	none	10-30% of littoral area of AU	n	R-cng	R-cng, Mxgrs	Dog, Will, Bber	Blmap, Dfir, Cdr	low	
3.03	10/24/02	L	revetment	none	riparian vegetation	path	road	industrial/commercial	none	51-100% of shoreline	n	none	none	none	none	none	none	1 pier or dock >8 feet wide	none	n	R-cng		Dog, Bber, Knot	Blmap, Ald, Will, Cottn, Cdr, Cher, Pine	moderate	
3.04	10/24/02	R	revetment	off-channel (two locations)	riparian vegetation	industrial/ commercial	#N/A	#N/A	none	51-100% of shoreline	n	none	none	none	none	none	none	none	none	n	R-cng	Mxgrs, R-cng	Bber, Knot, Will	Dfir, Cdr, Ald	moderate	due to restoration
3.05	10/24/02	L	revetment	none	riparian vegetation	road	#N/A	#N/A	none	51-100% of shoreline	n	none	none	none	none	none	none	none	none	n	R-cng		Dog, Will, Bber	Blmp, Ald, Lplain, Wwill	moderate	bank vegetation was good but limited by road
3.06	10/24/02	R	revetment	none	riparian vegetation	railroad	industrial/ commercial	#N/A	none	51-100% of shoreline	n	none	riprap	none	none	none	10-50% of shoreline below MHHW	none	none	n			Will, Bber	Blmap, Ald, Will	moderate	
3.07	10/24/02	L	revetment	none	riparian vegetation	industrial/ commercial	residential	#N/A	none	51-100% of shoreline	n	none	none	none	none	none	none	none	none	n			Dog, Bber, Knot	Dfir, Ald, Cher, Wwill, Lplain	low	
3.08	10/24/02	R	revetment	side-channel/ riparian enhancement	riparian vegetation	path	recreational	#N/A	none	51-100% of shoreline	y	none	riprap	none	none	none	10-50% of shoreline below MHHW	1 pier or dock >8 feet wide	none	n	R-cng		Will, Dog, Bber	Cottn, Blmap, Ald, Ash, Lplain	moderate	moderate, upper half would rate high, lower would rate moderate
3.09	10/29/02	L	revetment	none	riparian vegetation	vacant	industrial/ commercial	#N/A	none	51-100% of shoreline	n	none	none	none	none	none	none	none	none	n			Dog, Bboo, Knot, Bber	Cottn, Blmap, Ald, Lpop	high	
3.10	10/29/02	R	revetment	none	riparian vegetation	path	recreational	#N/A	none	51-100% of shoreline	n	none	none	none	none	none	none	1 pier or dock >8 feet wide	none	n		R-cng	Dog, Will, Spir, Bber	Blmap, Ash, Dfir, Filb, Lplain	moderate	Multiple willows overhanging water
3.11	10/29/02	L	revetment	none	riparian vegetation	path	industrial/ commercial	#N/A	none	51-100% of shoreline	n	none	none	none	none	none	none	1 pier or dock >8 feet wide	none	n		R-cng	Will, Dog, Knot, Bber	Blmap, Ash, Ald, Cottn, Dfir, Lpop	moderate	with areas of high
3.12	10/29/02	R	revetment	none	riparian vegetation	railroad	vacant	#N/A	none	51-100% of shoreline	n	none	riprap	none	none	none	none	none	none	n			Dog, Bber	Ash, Cottn, Will, Ald	high	
3.13	10/29/02	L	revetment	none	riparian vegetation	recreational	#N/A	#N/A	none	51-100% of shoreline	n	none	none	none	none	none	none	1 pier or dock >8 feet wide	none	n		R-cng	Dog, Will, Bber, Knot	Cottn, Blmap, Cdr, Ash, Ald, Dfir	high	
3.14	10/29/02	R	revetment	none	riparian vegetation	recreational	path	#N/A	none	51-100% of shoreline	n	none	none	none	none	none	none	1 pier or dock >8 feet wide	none	n		R-cng	Dog, Will, SnoB, Bber, Knot	Cottn, Ash, Dfir, Ald	high	
3.15	10/29/02	L	revetment	none	riparian vegetation	path	road	industrial/ commercial	none	51-100% of shoreline	n	none	other	none	other	none	none	2 or more piers or docks >8 feet wide, OR 1 pier or dock >25 feet wide	none	n			Dog, Will, Knot, Bber	Cottn, Ald, Filb, Blmap, Ash, Ocdr, Dfir, Wwill	high	
3.16	10/29/02	R	revetment	none	riparian vegetation	railroad	industrial/ commercial	#N/A	none	10-24% of shoreline	n	none	riprap	none	riprap	none	none	none	none	n		R-cng	Will, Bber	Ald, Ash, Blmap, Cottn	moderate	
3.18	10/29/02	R	revetment	none	riparian vegetation	industrial/ commercial	vacant	road	none	51-100% of shoreline	n	none	none	none	none	none	none	none	none	n			Will, Dog, Bber, Knot	Cdr, Cottn, Ald, Lpop	moderate	
3.20	10/29/02	R	revetment	none	riparian vegetation	road	railroad	residential	>10 feet wide and >50% of shoreline	51-100% of shoreline	n	none	none	none	none	none	none	none	none	n		R-cng	Dog, BB, Bber	Cottn, Ald, Will, Ash, Cher, Blmap	high	
3.22	10/29/02	R	revetment	riparian enhancement	riparian vegetation	residential	road	#N/A	none	25-50% of shoreline	n	none	none	none	none	none	none	2 or more piers or docks >8 feet wide, OR 1 pier or dock >25 feet wide	none	n			Dog, Will, Bber, Knot	Dfir, Cottn, Cher, Filb, Map, Lcst	low	
3.24	10/29/02	R	revetment	none	riparian vegetation	road	railroad	#N/A	none	none	n	none	riprap	none	none	none	none	none	10-30% of littoral area of AU	n			Bber		low	
4.01	10/29/02	L	revetment	riparian enhancement	riparian vegetation	path	road	industrial/ commercial	none	51-100% of shoreline	n	none	none	none	none	none	none	2 or more piers or docks >8 feet wide, OR 1 pier or dock >25 feet wide	none	n			Rose, Dog, SnoB, Knot, Bber	Will, Ald, Dfir, Ash, Cottn, Brch, Blmap, Sumac, Filb, Aple	low	
4.02	10/29/02	R	revetment	none	riparian vegetation	road	railroad	industrial/ commercial	none	51-100% of shoreline	n	none	riprap	none	none	none	none	none	none	n			Bber, Knot		low	

Appendix B - Field Data

AU	Survey Date	Bank	Bank Type	Restoration Type	LandUse_1	LandUse_2	LandUse_3	LandUse_4	Marsh	Riparian	Source of LWD Recruitment	LWD Density	Below OHW: Armoring Type	Below OHW: Substrate	Above OHW: Armoring Type	Above OHW: Substrate	Bulkheads	Piers/Docks	Overwater Structure	Routine Disturbance (Spills/ Dredging)	Grasses/ Sedges below OHW*	Vegetation above OHW: Grasses/ Sedges*	Vegetation above OHW: Shrubs*	Vegetation above OHW: Trees*	Vegetation Quality	Notes
4.03	10/29/02	L	revetment	none	riparian vegetation	path	road	#N/A	none	51-100% of shoreline	n	none	none	none	none	none	none	2 or more piers or docks >8 feet wide, OR 1 pier or dock >25 feet wide	none	n			Rose, Dog, SnoB, Bber	Blmap, Ash, Cottn, Ald, Cher, Dfir, Aple, Filb, Sumac, Oak	high	
4.04	10/29/02	R	revetment	side-channel	riparian vegetation	agricultural	residential	road	none	51-100% of shoreline	n	none	none	sand	none	none	none	none	none	n			Will, Bber, Bboo	Blmap, Cher, Ald, Ash, Lpop, Aple	low	
4.05	10/29/02	L	revetment	none	riparian vegetation	residential	#N/A	#N/A	none	25-50% of shoreline	n	none	riprap	none	riprap	none	10-50% of shoreline below MSL	none	none	n			Will, Bber, Knot, Eivy, Lrl	Blmap, Dfir, Cdr, Map, Wwill, Lcst, Tup	moderate	
4.06	10/29/02	R	revetment	none	riparian vegetation	road	residential	recreational	none	51-100% of shoreline	n	0.2 piece/30m of shoreline	none	none	none	none	none	none	none	n		R-cng	Will, Knot	Dfir, Fig	low	
4.07	10/29/02	L	revetment	none	riparian vegetation	residential	road	#N/A	none	51-100% of shoreline	n	none	other	none	none	none	10-50% of shoreline below MSL	2 or more piers or docks >8 feet wide, OR 1 pier or dock >25 feet wide	none	n	Car		SnoB, Will, Bber, Knot, Clts, Eivy	Blmap, Dfir, Cdr, Cher, Lcst, Smap, Oak, Lpop, Filb, Wwill, Cnut, Sprce	moderate	
4.08	10/29/02	R	revetment	none	riparian vegetation	road	residential	#N/A	none	51-100% of shoreline	y	none	riprap	none	none	none	10-50% of shoreline below MSL	2 or more piers or docks >8 feet wide, OR 1 pier or dock >25 feet wide	none	n			Will, Knot, Eivy, Bber	Ash, Cottn, Cdr, Dfir, Blmap, Wwill, Lcst	moderate	
5.01	10/29/02	L	revetment	none	riparian vegetation	path	industrial/ commercial	#N/A	none	51-100% of shoreline	n	none	riprap	none	none	none	10-50% of shoreline below MSL	2 or more piers or docks >8 feet wide, OR 1 pier or dock >25 feet wide	none	n	Car, Scps	R-cng	Will, Spir, Bber	Ald, Cottn, Brch, Lpop	low	
5.02	10/29/02	R	revetment	none	riparian vegetation	industrial/ commercial	#N/A	#N/A	none	25-50% of shoreline	n	none	riprap	none	none	none	51-100% of shoreline below MSL	2 or more piers or docks >8 feet wide, OR 1 pier or dock >25 feet wide	none	n	Car	R-cng	Bber, Knot, ScotB	Cher, Ash, Fig, Nut, Lcst	low	
5.03	10/29/02	L	revetment	none	riparian vegetation	road	vacant	residential	none	25-50% of shoreline	n	none	riprap	none	none	none	51-100% of shoreline below MSL	none	none	n	Car	R-cng	Dog, Bber, Knot	Blmap, Will, Lcst	low	
5.04	10/29/02	R	revetment	none	riparian vegetation	path	industrial/ commercial	#N/A	none	none	n	none	riprap	none	none	none	51-100% of shoreline below MSL	2 or more piers or docks >8 feet wide, OR 1 pier or dock >25 feet wide	none	n	Car	R-cng	Dog, Bber	Lpop, Brch	low	
5.05	10/29/02	L	revetment	off-channel	riparian vegetation	path	recreational	industrial/ commercial	none	none	n	none	other	none	none	none	51-100% of shoreline below MSL	1 pier or dock >8 feet wide	none	n	Car		Will, Bber, Knot	Ash, Cottn, Ald, Aple, Dfir, Filb, Lcst	low	
5.06	10/29/02	R	revetment	off-channel	riparian vegetation	industrial/ commercial	vacant	#N/A	>10 feet wide and >50% of shoreline	none	n	none	none	mud	none	none	none	none	none	n	Car, Scps		Will, Eivy, Knot, Bber	Cher, Smap, Wwill	low	
5.07	10/29/02	L	revetment	none	riparian vegetation	path	industrial/ commercial	vacant	none	51-100% of shoreline	n	none	riprap	none	none	none	10-50% of shoreline below MHHW	none	none	n	Car, Catt		SnoB, Rose, Bber	Cottn, Will, Brch, Cher	high	
5.08	10/29/02	R	revetment	none	riparian vegetation	industrial/ commercial	road	#N/A	none	none	n	0.2 piece/30m of shoreline	riprap	none	none	none	51-100% of shoreline below MSL	2 or more piers or docks >8 feet wide, OR 1 pier or dock >25 feet wide	none	n			Will, Bber	Blmap, Cottn, Cher, Brch, Cdr	low	
5.09	10/25/02	L	revetment	levee set-back	riparian vegetation	industrial/ commercial	#N/A	#N/A	>10 feet wide and >50% of shoreline	51-100% of shoreline	n	0.2 piece/30m of shoreline	riprap	mud	riprap	none	51-100% of shoreline below MSL	2 or more piers or docks >8 feet wide, OR 1 pier or dock >25 feet wide	none	n	Catt	R-cng	Will, Hthne, Bber, Knot	Brch, Cher, Lpop, Wwill	moderate	
5.10	10/25/02	R	revetment	levee set-back	riparian vegetation	road	industrial/ commercial	#N/A	none	51-100% of shoreline	n	none	other	none	none	none	51-100% of shoreline below MSL	2 or more piers or docks >8 feet wide, OR 1 pier or dock >25 feet wide	none	n		Tnze	Rose, SnoB, Spir, BB, Bber	Blmap, Brch, Dfir, Pine, Wwill, Aspn, Oash	moderate	

Appendix B - Field Data

													Below OHW		Above OHW							Vegetation above OHW				
AU	Survey Date	Bank	Bank Type	Restoration Type	LandUse_1	LandUse_2	LandUse_3	LandUse_4	Marsh	Riparian	Source of LWD Recruitment	LWD Density	Armoring Type	Substrate	Armoring Type	Substrate	Bulkheads	Piers/Docks	Overwater Structure	Routine Disturbance (Spills/ Dredging)	Grasses/ Sedges below OHW*	Grasses/ Sedges*	Shrubs*	Trees*	Vegetation Quality	Notes
5.11	10/25/02	L	revetment	none	riparian vegetation	vacant	road	industrial/ commercial	none	51-100% of shoreline	n	none	riprap	none	none	none	none	none	none	y	Catt, Car, Scps, Rush	Tnze, R-cng,	Will, Rose, Snob, Dog, ScotB, Bber, BB	Blmap, Cottn, Ald, Ash, Cher, Cdr, Heml, Pine, Lcst	moderate	moderate and expected to improve due to riparian enhancement projects.
5.12	10/25/02	R	revetment	none	industrial/ commercial	#N/A	#N/A	#N/A	none	51-100% of shoreline	n	0.2 piece/30m of shoreline	riprap	none	none	none	51-100% of shoreline below MSL	none	none	y		R-cng	Will, Bber	Blmap, Brch, O aspn, O-egrn	low	
5.14	10/25/02	R	revetment	none	industrial/ commercial	#N/A	#N/A	#N/A	none	none	n	none	riprap	none	riprap	none	51-100% of shoreline below MSL	none	30-50% of littoral area of AU	y					low	
5.16	10/25/02	R	revetment	levee set-back/ riparian enhancement	riparian vegetation	industrial/ commercial	#N/A	#N/A	none	25-50% of shoreline	n	0.2 piece/30m of shoreline	riprap	none	riprap	none	51-100% of shoreline below MHHW	none	none	y			Will, Bber, Knot, ScotB	Ash, Oak, Blmap, Mad, Cottn, Brch, Lpop	low	
5.18	10/25/02	R	revetment	none	industrial/ commercial	#N/A	#N/A	#N/A	none	none	n	none	other	none	other	none	51-100% of shoreline below MSL	none	none	y			Bber, BB, ScotB	Blmap, Ash, Brch	low	
5.20	10/25/02	R	revetment	bench/riparian enhancement	riparian vegetation	industrial/ commercial	#N/A	#N/A	none	51-100% of shoreline	n	none	riprap	none	riprap	none	51-100% of shoreline below MHHW	none	none	y			Dog, BB, Bber	Ash	low	
5.22	10/25/02	R	revetment	bench/riparian enhancement	industrial/ commercial	#N/A	#N/A	#N/A	none	none	n	none	other	none	other	none	51-100% of shoreline below MSL	2 or more piers or docks >8 feet wide, OR 1 pier or dock >25 feet wide	50-75% of littoral area of AU	y			Bber		low	
5.24	10/25/02	R	revetment	bench/riparian enhancement	riparian vegetation	industrial/ commercial	#N/A	#N/A	none	10-24% of shoreline	n	none	other	none	riprap	none	51-100% of shoreline below MSL	none	50-75% of littoral area of AU	y		R-cng	Bber	Ash	low	
5.26	10/25/02	R	revetment	none	industrial/ commercial	#N/A	#N/A	#N/A	none	none	n	none	other	none	none	none	51-100% of shoreline below MSL	none	50-75% of littoral area of AU	y					low	

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* See Table B1 for key to field code abbreviations (grasses, sedges, shrubs, trees).

Table B1

Type	Species	Field Code
Below OHW		
Grasses and Sedges	Carex	Car
	Cattail	Catt
	Rush	Rush
	Scirpus	Scps
Above OHW		
Grasses	Cattail	Catt
	Mixed native grasses	Mxgrs
	Reed canarygrass	R-cng
	Tansy	Tnze
	Tufted hairgrass	Hair
Sedges	Carex	Car
	Bulrush	Bul
Shrubs	Bamboo	Bboo
	Blackberry	Bber
	Butterfly bush	BB
	Clematis	Clts
	Dogwood	Dog
	English ivy	Eivy
	Hardhack	Spir
	Hawthorne	Hthne
	Japanese knotweed	Knot
	Juniper	Jnpr
	Laurel	Lrl
	Pacific silverweed	Psilv
	Rose	Rose
	Scot's broom	ScotB
	Snowberries	SnoB
	Vine maple	Vmap
	Willow	Will

Type	Species	Field Code
Above OHW		
Trees	Apple	Aple
	Aspen	Aspn
	Bigleaf mable	Blmap
	Birch	Brch
	Black cottonwood	Cottn
	Blue spruce	Bsprce
	Cedar	Cdr
	Cherry	Cher
	Chestnut	Cnut
	Douglas fir	Dfir
	Evergreens	Egrn
	Fig	Fig
	Filbert	Filb
	Hawthorne	Hthne
	Hemlock	Heml
	Locust	Lcst
	Lombard poplar	Lpop
	London plains	Lplain
	Madrone	Mad
	Maple	Map
	Maple	Map
	Mountain ash	MAsh
	Nut	nut
	Oaks	oaks
	Oregon Ash	Ash, Oash
	Ornamental aspen	O-Aspn
	Ornamental cedar	Ocdr
	Ornamental evergreen	O-Egrn
	Ornamental fir	Ofir
	Pines	Pine
	Red alder	Ald
	Red maple	Rmap
	Silver maple	Smap
	Sumac	sumac
	Tupalo	Tup
	Weeping willow	WWill

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